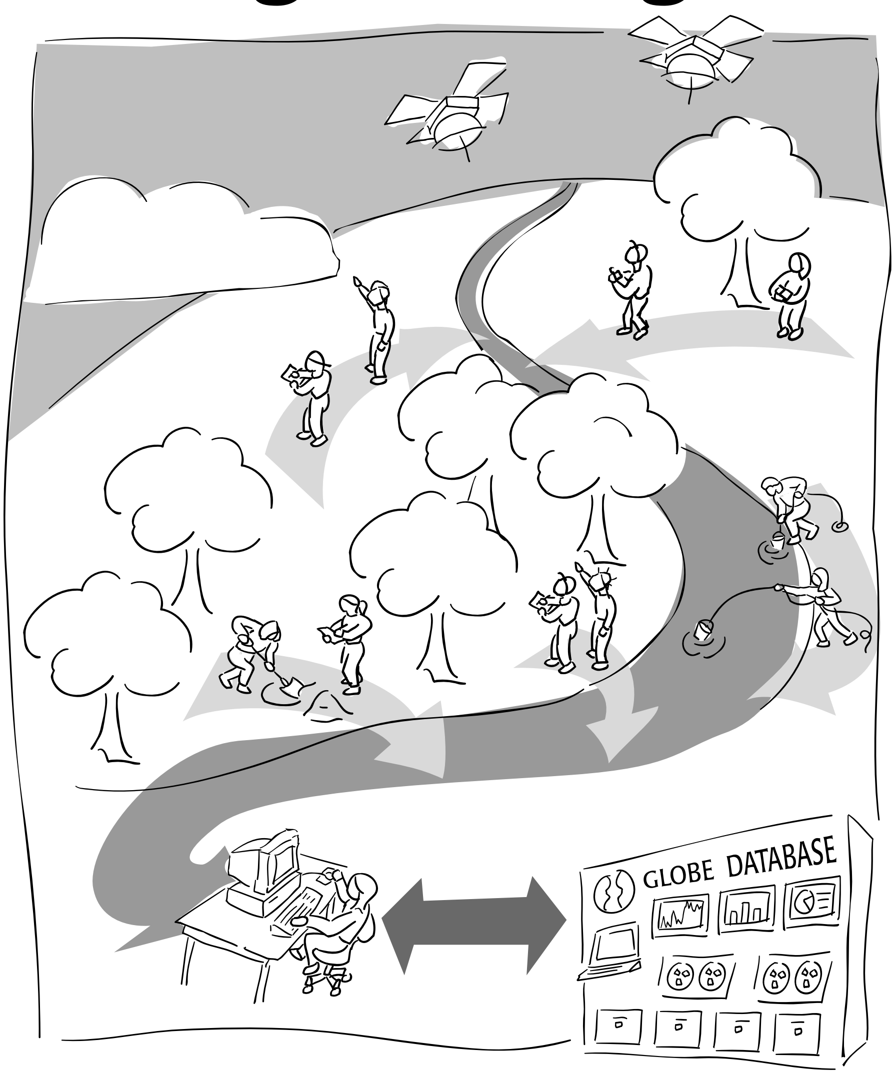
Seasons Investigation

Putting It All Together



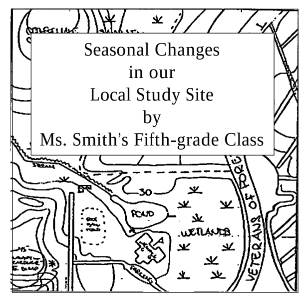
A GLOBE™ Learning Investigation

Seasons Investigation at a Glance

Protocols

No protocols in this investigation

Suggested Sequence of Activities



Students read Scientists' letter

Do the Learning Activities:

What Can We Learn About Our Seasons?

What Are Some Factors That Affect Seasonal Patterns?

How Do Seasonal Temperature Patterns Vary Among Different Regions of the World?

What Can We Learn by Sharing Local Seasonal Markers with Other Schools Around the World?

Students design and implement their own investigations in other domains.

Special Notes

This is a set of Learning Activities to help students learn how to do their own science investigations and to integrate the protocols from the other investigations.

Table of Contents

Scientists' Letter to Students

Duplicate and distribute to students.

Dear Students,

Principal Investigator Dan Barstow expresses the "Wow!" of science education.

This investigation is a little different from the others. Rather than ask you for new data, you will be able to investigate questions that interest you. In the process of doing your own research, we hope you will learn key science concepts and better understand what science is about.

As you explore your study site, keep track of questions that interest you. Why is the soil wet in one area and dry in another? Why are there so many different types of land cover in your study site? Why do things change so much every season?

Also keep track of questions as you look at data from the other schools around the world. Where are the coldest and warmest places in the world? What is the most common type of land cover reported by schools within 500 miles of your school? What other areas of the world have the same type of land cover? Why?

Principal Investigator Boris Berenfeld

These activities focus on seasons. Seasonal changes directly impact our lives. What are the coldest and warmest days of the year at your site? Are these the same every year? Are they the same all over the world? Can you tell what season it is by looking at a satellite photo of Earth from space? Yet, what makes seasons change is not obvious.

The Seasons investigations provides you with a wonderful opportunity to figure out the answers to your questions by looking at the actual data from other schools. This is how scientists learn – they observe the real world, ask questions, collect data, explore the data, ask more questions, and try to figure out what is going on. You will have a chance to design your own investigations and collaborate with other students all over the world to do your research. Ultimately, you will see how your local community fits into the global environment.

Once you feel comfortable with doing scientific investigations, we hope you will design investigations based on any question that interests you.

Dan Barstow (Principal Investigator)

Boris Berenfeld (Principal Investigator)

Harold McWilliams (Project Director)

Chris Randall (Senior Curriculum Developer)

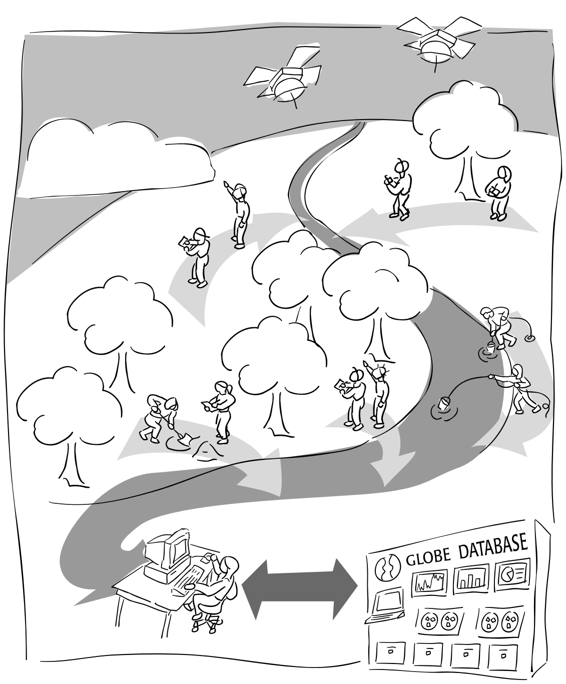
Introduction

The Big Picture

GLOBE student observations of the atmosphere, surface water, soil moisture and temperature, and vegetation all are impacted by seasonal changes as Earth orbits the Sun. These seasonal changes illustrate the interconnectedness among these aspects of our environment. Many important seasonal phenomena and regional differences can be studied based on the environmental and climatic parameters measured in the GLOBE program. Seasonal change is a response to increasing or decreasing levels of solar energy input, and GLOBE measurements are windows into these changing energy levels.

The Seasons investigation integrates science concepts and data from the various protocols. Your students will explore annual planetary changes – seasons – as a focal point for integrative learning. This chapter has two major areas of emphasis:

1. Learning science content – Helping students learn about seasonal cycles and helping them explore the interconnectedness among all aspects of the Earth system



2. Developing investigation skills – Helping students learn how to design and conduct their own GLOBE investigations

The concept of seasons is simple enough for students of all ages to grasp, and yet, it can be investigated at many levels. For K-3 students, the goal of the Seasons chapter is to observe many of the changes that occur throughout the year and to understand their observations and measurements as windows into large-scale, complex changes. For intermediate and advanced students, an additional goal is to understand the factors that underlie the differences in seasonal patterns around the world.

Why Are There Seasons?

Like tides washing regularly across a beach, seasons advance and retreat across the face of the globe and bring changes that transform the face of the Earth. Whether it is the arrival of the winter snows, the monsoon rains, or the summer heat, our environment changes constantly, and these profound changes occur over relatively short time periods. What helps make such huge, complex changes comprehensible is that they reoccur in predictable ways. Many ancient civilizations observed that the Sun's position in the sky changed throughout the year and were able to construct calendars and predict seasonal change based on their observations.

All seasonal changes are driven by changes in the amount of the Sun's energy reaching the Earth's surface (i.e., the amount of *insolation*). For example, more energy leads to higher temperatures which results in more evaporation which produces more rain which starts plants growing. This sequence describes Spring at mid-latitudes. Since visible light is the main form of solar energy reaching Earth, day length is a reasonably accurate way to gauge the level of insolation and has long been used as a way to understand when one season stops and the next one starts. For example, the first day of summer (the *summer solstice*) is the longest day of the year. Winter starts on the shortest day of the year, the *winter solstice*. The first days of fall and spring are when the day and night are of equal length – roughly 12 hours each. These days are named the *vernal* and *autumnal equinoxes*.

Changing day length implies that the Earth's axis of rotation is inclined with respect to the plane of its orbit around the sun. The ancient Greeks knew that the Earth was inclined 23.5°. Figure SE-I-1 shows the inclined Earth at different positions in its orbit. Notice how at the solstice positions, each pole is tilted either toward or away from the Sun. The pole inclined toward the Sun receives 24 hours of sunlight, and the one inclined away is in the Earth's shadow and experiences 24 hours of darkness. At the equinox positions, the Earth is inclined in a way so that each pole receives equal amounts of insolation. This discussion focuses on the poles because they experience the greatest extremes of insolation. Because of the inclination of the Earth's axis, insolation levels at every point on Earth change constantly. We call the effects of these changing levels seasons.

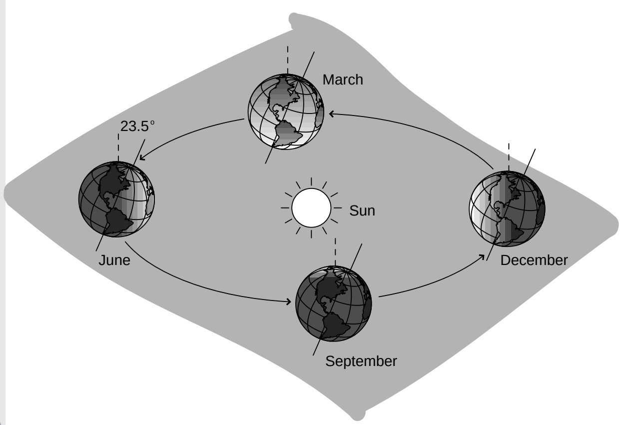


Figure SE-I-1: Positions of Earth in relation to the sun on the solstices and equinoxes

Latitude

Figure SE-I-2 shows how insolation levels vary with latitude. Because of this variation, latitude has a powerful influence in determining seasonal conditions and the annual patterns of environmental and climatic parameters such as precipitation and temperature.

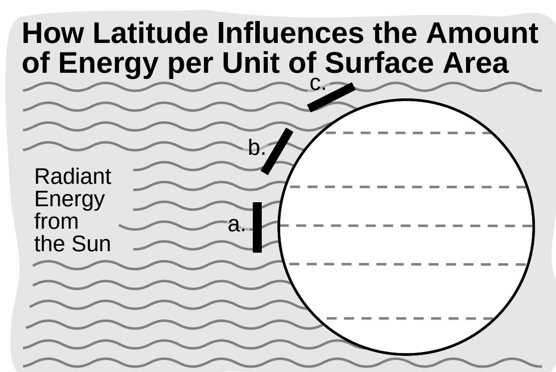
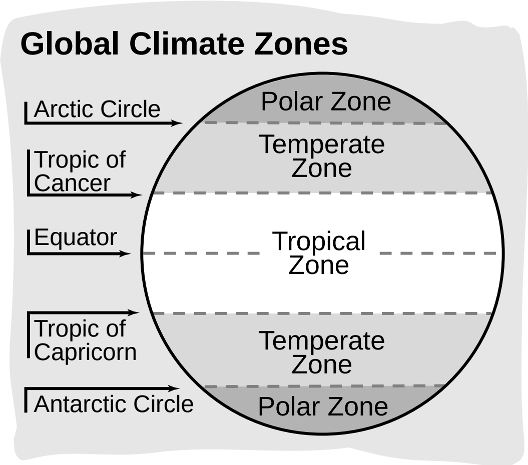


Figure SE-I-2: Areas a, b, and c are all the same size, yet they all receive different amounts of the sun's "rays."

Different Climatic Zones

The same season can be quite different in the *Tropical*, *Temperate* and *Polar* zones. These seasonal differences are based on the duration and directness of insolation. See Figures SE-I-2 and SE-I-3.

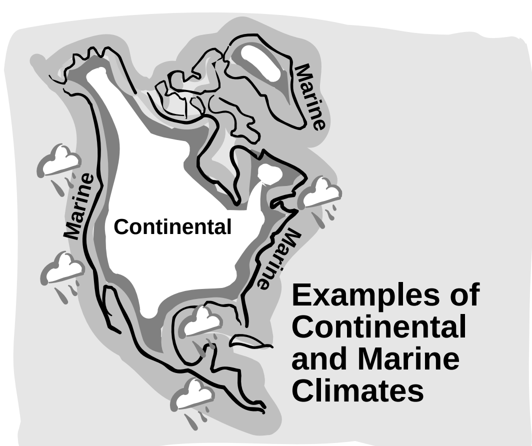
Figure SE-I-3



Continental and Marine Climates

Marine climates have larger amounts of moisture and smaller temperature changes from summer to winter than continental climates. However, the size of a continent affects both the temperature range and the amount of moisture in the interior – the larger the continent, the larger the effect. See Figure SE-I-4.

Figure SE-I-4

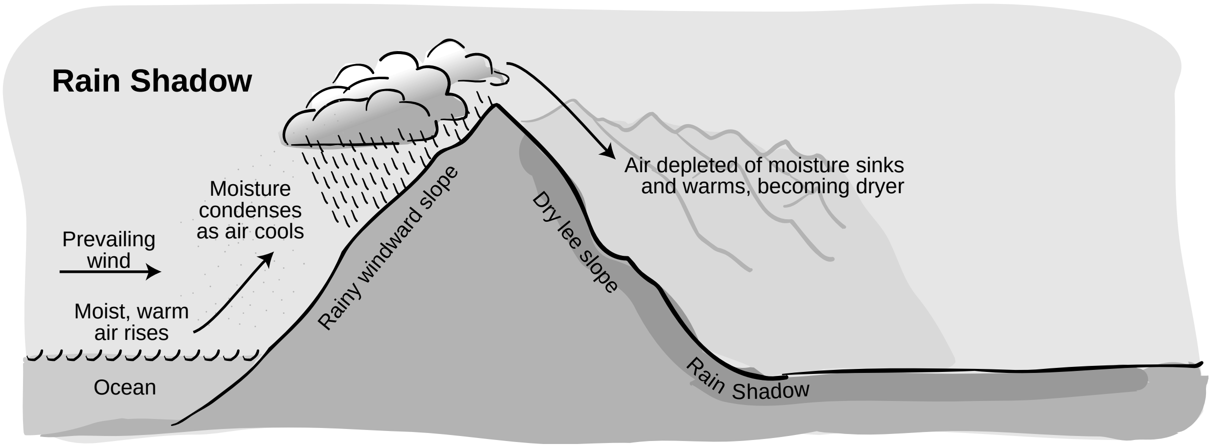


Two Key Factors That Affect Precipitation Levels

Amount of Water Vapor: Evaporation is how most of the water vapor enters the atmosphere, and air near large bodies of water such as oceans have the highest levels of water vapor. Also, higher temperatures increase evaporation rates. Consequently, air in tropical regions downwind from large sources of water tends to have the highest levels of water vapor, while air in temperate and polar regions in the center of large continents tends to have the driest air. In this example, *geography* influences amount of water vapor that influences precipitation levels.

Temperature: Though evaporation increases as temperatures rise, warm air holds more moisture than cool air. Warm air can cool in several ways. On a local level, the atmosphere cools at night, and the morning dew is the result of the water vapor condensing on cool surfaces. Warm air masses can move to cooler locations. Many storms start as warm, humid air masses that move to higher, cooler altitudes and latitudes. In this example, *latitude* influences temperatures which influence precipitation levels. Finally, increases in elevation cause air to cool. Generally, the atmosphere cools 1°C for every 150 meter rise in elevation. A considerable percentage of the water vapor in air rising over mountains condenses and falls as precipitation. In this example, *elevation* and *geography* influence temperatures which influence precipitation levels.

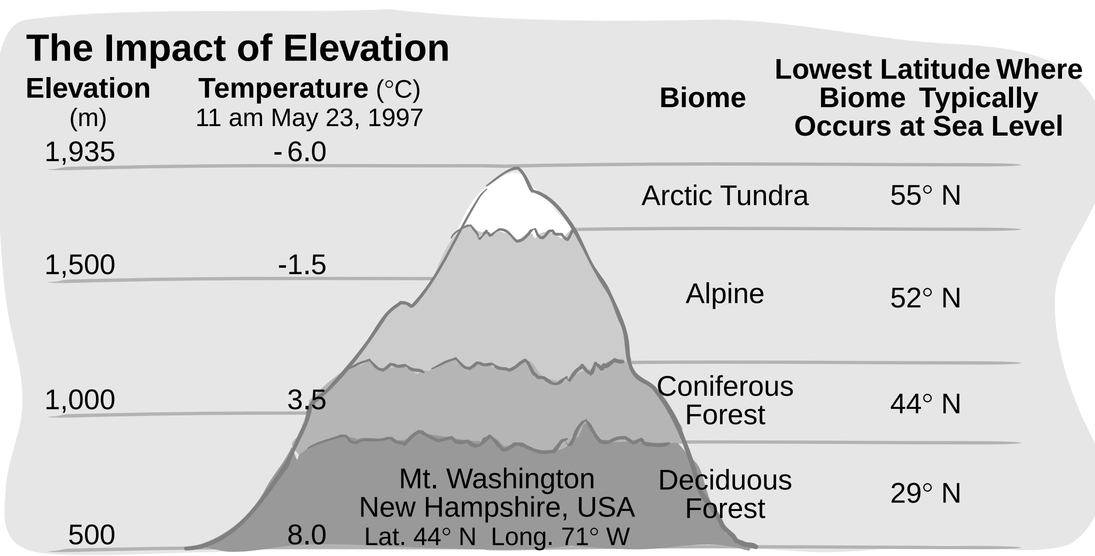
Figure SE-I-5



Geographical Features

Geographical features have profound impacts on nearby regions. For example, mountain chains can cause moist air to rise and precipitate out almost all of its moisture. When this *desiccated* (depleted of moisture) air descends to the regions behind the mountain chain, it creates a *rain shadow*. See Figure SE-I-5. Many deserts are found in such rain shadows. In addition to arid land, typical desert regions lack the atmospheric moisture that acts as insulation between the Earth's surface and space (water is the major greenhouse gas on Earth). Consequently, desert areas easily radiate their heat energy out to space, and day and night temperature differences are considerable.

Figure SE-I-6: A comparison of elevation, temperature, biome and latitude on Mt. Washington



Elevation

Changes in elevation can affect the environment as much as changes in latitude. Temperature falls approximately 1°C for every 150 meter increase in elevation, and, in terms of growing season, every 300 m increase in elevation is roughly equivalent to moving toward the nearest pole by 400-500 km (roughly four to five degrees of latitude). Mountain tops can be thought of as climatic islands where, in the Northern Hemisphere, northern species extend their ranges southward onto mountains where conditions resemble those of more northern latitudes. Plants growing on the top of New Hampshire's Mt. Washington (1,935 m) would feel right at home growing at sea level in the Arctic tundra, 2,400 km to the north in Canada. See Figure SE-I-6.

Global Energy Transfer Systems

As illustrated in Figure SE-I-2, the tropics receive more energy from the sun per unit of surface area than temperate or polar zones. In fact, even though the warmer tropics radiate more heat to space than high latitude regions, the tropics receive more energy from the sun than they radiate away! Where does this excess energy go? The circulation of the atmosphere and the oceans carries this energy, in the form of heat, to higher latitudes. See Figure SE-I-7.

If we consider the average north-south motion of the atmosphere, warm air from near the equator rises and moves toward the poles. At roughly 30° latitude, the air cools, falls and moves equatorward near the surface. A similar pattern exists in the polar zones, with air rising at roughly 60° latitude and falling at the poles. Since the tropical and polar zones bracket the temperate zones, the tropical and polar circulations drive the circulation patterns of the temperate zones. As a result, the air in temperate zones moves poleward at low altitudes, rises at roughly 60°, returns equatorward aloft and falls at roughly 30°.

In the oceans, strong currents such as the Gulf Stream, the Brazil, the East Australia, and the Kuroshio carry warm water from the tropics to latitudes of roughly 50°. Less prominent currents also contribute to this heat transport. Consequently, regions at high latitudes adjacent to an ocean, such as Ireland, have climates typically associated with regions at lower latitudes.

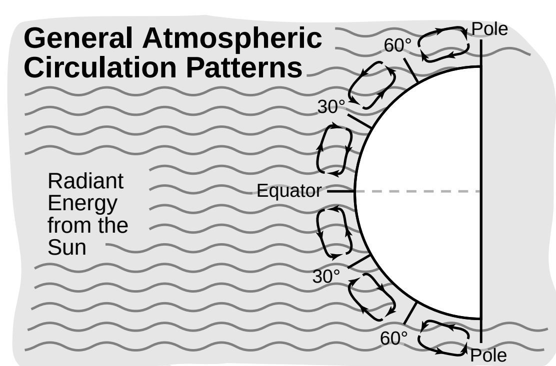
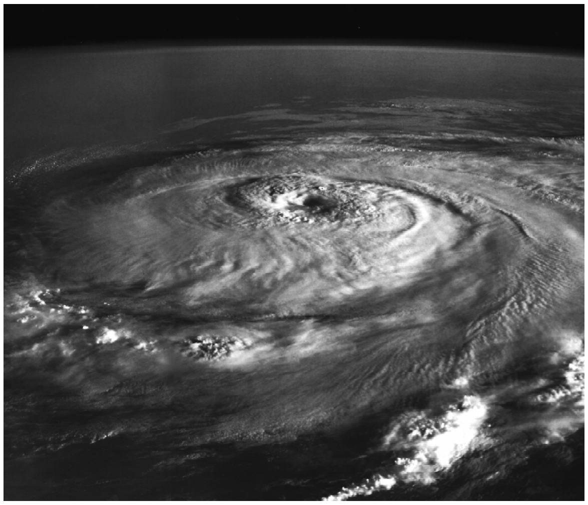


Figure SE-I-7: The rising of heated air and the sinking of cooled air drives atmospheric convection cells.



How Are Components of the Earth System Impacted by Seasonal Changes?

The atmosphere is perhaps the most obvious in its seasonal changes. There are annual cycles in temperature and precipitation. Hurricanes and tropical storms are season-dependent, as are droughts and monsoons. Storm systems result from large-scale movements of air masses that are strongly affected by seasonal changes.

Earth's ecology has adapted to Earth's seasonal changes in some remarkable ways. Animals migrate during the year to avoid extreme conditions. Most species have annual reproductive cycles. Plants have their highest photosynthesis levels in the summer when the sun is highest, and then some drop their leaves so that they do not drain their energy resources during the winter. Seeds germinate when soil temperature and moisture are favorable.

Soil conditions vary seasonally. For example, seasonal biological changes such as leaves falling enrich the soil. Soil conditions also vary seasonally as a result of changes in precipitation patterns, and your students might find differences in the rate at which rain soaks into the ground at different seasons.

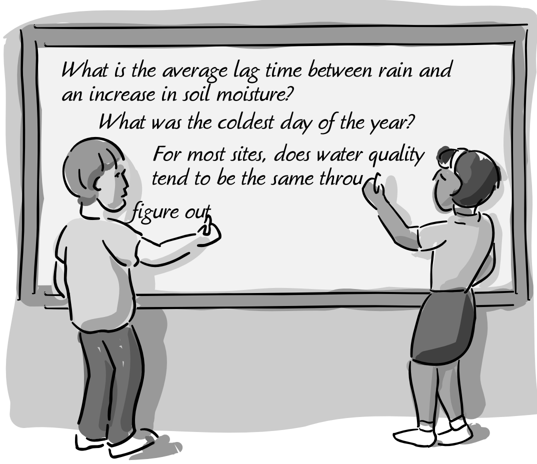
The hydrologic cycle shows seasonal changes in all aspects of the water cycle. Rainy and dry seasons affect the quantity and quality of water in rivers and lakes. Catastrophic flooding can occur in spring as winter snows melt. Seasonal monsoons are essential for the replenishment of water reserves in many parts of the world.

Students' Own Investigations Teach Research Skills

This chapter is a set of integrated student activities. Within the broad domain of seasons, students ask questions, speculate about ideas, observe their study sites, collect and analyze data, communicate with other students and scientists, use multiple sources of information, and communicate their findings.

By doing such investigations, students learn how to do scientific research. In addition, this hands-on, inquiry-based approach is also a powerful way for students to learn science content. By designing and implementing their own investigations, students engage in multidimensional learning that is far more effective than reading science in textbooks.

In these activities we emphasize the analysis of local as well as global data. The best investigations emerge from the questions that the students themselves ask as they observe their study sites and explore the GLOBE database. Be alert for questions that can serve as springboards for investigations. As questions come up, have students record them in their GLOBE Science Notebooks.



An Overview of Student Assessment in the Seasons Investigation

Since student investigations are a major focus of the Seasons Investigation, your evaluation should emphasize assessing the quality of their investigations. While specific assessment questions are listed at the end of each activity, we suggest that you evaluate your students' progress at three stages of their investigations:

1. In the early stages, what kinds of questions are they asking?
Your students should demonstrate a questioning attitude as they observe their study site and look at the GLOBE data. Their questions should show genuine personal curiosity and be based on a novice's understanding of the science domain. As the students select questions for further investigation, they should have a reasonable chance of finding answers with further observations of the study site or deeper analysis of GLOBE data.

2. In the middle stages, are they able to make sense of the data?
This stage emphasizes the use of study site observations and GLOBE data. For younger students, do they observe carefully, record their observations accurately and find patterns in their observations? For older students, do they understand the measurements on which the GLOBE data are based, are they able to use graphs and maps to analyze the data, and do their analyses make sense?

3. In the later stages, are they able to communicate findings to others?
When they complete their investigations, students need to be able to share their findings with you, their classmates, GLOBE scientists, and students throughout the world, and the general public. Whether their communications are in written or verbal form, do the students demonstrate a clear understanding of their investigations? Do they understand the underlying systems they are investigating and the relationships within such systems? Are they able to communicate clearly to their audience? Does the investigation itself show the depth and quality that you expect from a student at this level?

We also encourage you to assess students' understanding of content and interconnections. Students could, for example, construct concept maps (if this is a device you use) or reports or displays that explain the systems and causal connections that they've been investigating.

Implementation Recommendations

1. Do at least one learning activity from another protocol.
The Seasons Investigation is best implemented after your students have begun exploring their study sites and begun collecting and submitting data for at least one of the protocols. It is even better if you have data from additional protocols, either from your own class or from other collaborating classes in your school or district.

2. Accumulate data over the full year.
Exploring seasonal changes requires having enough data for your students to begin to identify changes over the course of the full year. This underscores the importance of beginning your measurements early in the year and doing them regularly, as detailed in the protocols. If your school has been in GLOBE less than one year, you can use data from a nearby school or from several weather data bases available in the GLOBE Resource Room. Some of these data bases have data from thousands of stations going back several hundred years, in some cases.

3. Promote a questioning attitude all the time.
With GLOBE investigations, and in real science research, an important skill is the ability to ask interesting questions. You can make questioning a more important part of your classroom by encouraging students to record their questions in their GLOBE Science Notebooks and by reviewing these questions from time to time.

4. Use the Student Data Server and GLOBE Visualizations
In the Seasons chapter, your students will make use of the GLOBE Student Data Archive and GLOBE Visualizations. The maps, satellite images, visualizations, data base and data analysis tools are extremely powerful resources for your students to pursue their own investigations. The appendix has detailed instructions to help students access and use the data and tools called for in each activity.

Key Concepts and Skills in the Seasons Investigation

Concepts

- Seasonal changes demonstrate the interconnections among the Earth's systems.
- Environmental and climatic parameters follow predictable cycles over the course of a year;
- Environmental and climatic parameters respond to changing levels of insolation, with some responding more dramatically than others;
- Seasonal markers respond directly to the level of environmental and climatic parameters;
- Different regions experience seasons differently, and factors such as latitude, elevation, and geography impact local seasonal patterns.

Skills

- *Graphing* GLOBE data to show seasonal patterns.
- *Comparing* graphs and *analyzing* data.
- *Asking* questions and *developing* hypotheses.
- *Designing* and *implementing* investigations
- *Drawing* conclusions and *communicating* them to others.

What Can We Learn About Our Seasons?

Students develop a qualitative understanding of the characteristics and patterns of seasons and highlight the relationship of seasons to physical, biological and cultural markers.

What Are Some Factors That Affect Seasonal Patterns?

Students use GLOBE data and graphing tools to compare the influence of latitude, elevation, and geography on seasonal patterns.

How Do Regional Temperature Patterns Vary Among Different Regions of the World?

Students use GLOBE visualizations to display student data on maps and to learn about seasonal changes in regional and global temperature patterns.

What Can We Learn by Sharing Local Seasonal Markers with Other Schools Around the World?

This activity promotes collaborations among teachers during and after the GLOBE teacher training program. It helps teachers and students learn how to work with the GLOBE data system and GLOBEMail email. It also helps teachers and students learn how the protocols are inter-connected and can support inquiry-based investigations.

What Can We Learn About Our Seasons?

Purpose

Students develop a qualitative understanding of the characteristics and patterns of seasons and highlight the relationship of seasons to physical, biological and cultural markers.

Overview

Students observe and record seasonal changes in their local study site. They establish that these phenomena follow annual cycles and conclude the activity by creating displays that illustrate the repeating pattern associated with the appearance and disappearance of seasonal markers.

Time

Ongoing

One class period per month to visit the GLOBE study site; one or two additional class periods per month to record, graph, and discuss observations

Note: There is some advantage in designing a schedule for Study Site visits which corresponds to the data collection visits used in the protocols.

Level

All

Adapting the Activity to Different Levels:

Beginning: as described here

Intermediate: Discuss the strengths and weaknesses of qualitative data.

Advanced: Require more detailed observations of seasonal transitions. Also, discuss whether it is a coincidence that many cultural celebrations correlate with the solstices and equinoxes.

Key Concepts

Seasons have distinct characteristics.

Seasonal changes can be observed in our study site.

Seasonal changes follow an annual cycle.

Through careful observation, you can begin to understand seasonal patterns.

Skills

Observing seasonal changes

Recording observations in GLOBE science journals

Organizing observations in tables and graphs

Representing information with pictures, numbers, and photographs

Materials and Tools

Large sheets of paper

Colored markers

Glue

GLOBE Science Notebooks

Prerequisites

None

Background

The purpose of this activity is to engage your students in careful observations of the seasonal changes that occur in their GLOBE study site. Because we want them to be active participants in planning what they will observe, we ask them to predict which things they think will change in the study site. We then ask them to make careful observations and to compare these with their predictions. When they have collected observations over an extended period of time we ask them to identify trends in the phenomena and to predict “what will happen next” and why. In Step 6 we ask them to think about how the changes they observe are interrelated and in Step 7 to relate the observations to the conventional astronomical markers of seasons (solstices and equinoxes). The activity concludes by asking students to create a profile of each local season using their own observations and, if they wish, to share this with another GLOBE school using GLOBEMail.

We envision this as an activity that continues throughout the school year, with students adding observations on a periodic basis. As the teacher, you will need to decide how often students will visit the study site to make observations. If your site is readily accessible, you may be able to visit as often as once a week, especially during times of the year when many things are changing. But if this is not feasible, try to visit the site monthly. These visits can be supplemented by asking students to make observations near the school, looking out the window, at home, and as they travel to and from the school. If you keep separate records of changes observed at different local sites, you can discuss how the different sites compare.

Understanding what causes seasons is not the primary goal of this activity. Rather, it should be viewed as an introductory activity that focuses students on making careful observations, recording these observations in a systematic way, and noticing the annual cycles that their observations reveal. Remember that GLOBE is an international program and that seasonal changes are quite different in different parts of the world where GLOBE schools are located. This is a wonderful asset of the GLOBE program! We suggest that you contact a GLOBE school in another part of the world and share information with them on your seasonal observations.

Procedure

1. Ask students to think about the seasons that occur in their GLOBE study site. How would they characterize the local seasons? How many seasons are there? What are they called? When do they begin and end? Compose a description of local seasons that the class can agree on.

2. Brainstorm about change.

   Ask students to think about things that are likely to change in their GLOBE study site during the course of the year as the seasons change. Organize them in small groups and ask each group to make a list of all the changes they think might take place. One way to do this is to think about how the study site will change during each month of the year. Guide them to think about changes such as:

   - changes in plant life and vegetation, e.g. blossoming of trees and flowers, leaves dropping, grass turning brown, the appearance of certain fruits
   - changes in animal behavior, e.g. birth of babies, hibernation, migration
   - changes in the physical environment, e.g. getting warmer or colder, rainier or drier, freezing or thawing of bodies of water.

   Have a whole-class discussion of all the changes that the small groups have recorded. Create a composite list for the entire class of changes that you think will occur in the study site during the course of a year.

3. Record actual observations.

   The point now is to begin to observe systematically the kinds of changes that students listed in the preceding step. Help students develop an organized system of recording changes that they observe in the study site. If they have GLOBE Science Notebooks, they can record their observations there. But, in addition, they should record the observations in a form that can be displayed and viewed by the entire class for purposes of discussion. Particularly with younger students, the format should be large and easy to understand. One possibility is to use large sheets of chart paper, one paper per observation period. All the observations made during a given week or month can be recorded on a single large sheet of paper. The paper can then be hung in the classroom, attached to a bulletin board, or displayed in the hallway. As the students make other visits to the study site they can record their observations on separate sheets and add them to the display. The sheets can include sketches, leaves, blossoms, or buds collected (fastened on with glue), photographs the students took, numerical data they might have gathered, and "impressions" they might have recorded in prose or poetry.

4. Review the changes that have been observed in the study site.

   Once the students have made some observations and recorded them, it will be valuable to review them in light of the lists produced in Step 2. Compare the actual observations with the expectations. As you accumulate data over time, discuss how the study site changes from one visit to another. What were the changes in vegetation, the water, the animals that live there, the moisture, the temperature, etc. Refer to the observations made during the previous visit to form comparisons. If the observations have been recorded on large sheets of paper, then it will be easy to refer to them during the discussion. Ask students to talk about what has changed and what has not changed. As a concluding activity, summarize the changes that have been observed. For younger students, the teacher can write down summaries of what the students say; older students might write a summary in their GLOBE Science Notebooks.

5. Predict and explain.

   Ask students to predict, based on what they saw on this visit and the last, what changes they expect in the study site on the next visit. Ask them to think about what is happening in the study site, what is happening with the season. What trends do they see developing? Do they think the temperature will be colder or warmer next time? Will the site be wetter or drier? Will the vegetation be more leafed out or less? Whatever observations they are tracking, ask them to predict what they think the next period's observation will bring. Ask them to explain why they expect the changes they predict. (This will also give you an insight into their reasoning process.) What do they think might be causing the changes they predict? Record these predictions on a large sheet of paper and keep it for comparison with the actual observations next time. You may also want students to record one or more predictions in their GLOBE Science Notebooks.

6. Explore relationships among changes.

   The changes that students are observing in their study site are not occurring in isolation. They are interrelated parts of seasonal change. Ask students to think about and discuss the possible relationships among the phenomena or parameters that are changing. Ask them to discuss, for example, how changes in air temperature are related to changes in animal behavior; how changes in moisture in the ground are related to changes in plants that are growing in the ground. Look for as many relationships as possible. Ask students to explain why they think these phenomena are related to each other. As a class, write down why you think these things are related. Also ask students to write about these relationships in their GLOBE Science Notebooks.

7. Relate the observations to the conventional seasons.

   The summer and winter solstices and the vernal and autumnal equinoxes define the conventional seasons. Explain to students that these are special days in the annual calendar, and that they are marked as the longest and shortest days and the days that have equal amounts of daylight and darkness. Ask students to think about the condition of their study site in relation to these divisions of the year. What changes do they observe that might coincide with these astronomical markers? Using the data they collect, ask students to see where they think each season actually "should" begin and end. Ask them to think about whether there are any easily defined, sharp markers of the beginning and end of each season.

8. Create a profile of your seasons.

   As a culminating activity, ask students, perhaps working in small groups, to create a profile of each local season based on the observations they have made. (This activity may have to wait until you have collected sufficient data.) Ask the students to characterize not only the "height" of a season but also the transition points between seasons. Ask them to think about how the observed phenomena mark the beginning, the height, and the end of each season. Consider whether the seasons begin abruptly or gradually. For example, in monsoon areas, the onset of the first monsoon rain begins suddenly, followed by a more gradual drop in temperature. Consider sharing the profiles you create with another GLOBE school through GLOBEMail.

Assessment

- Ask students to select one aspect of the study site that they have studied, such as trees, and to describe how trees change in the study site over the course of a year. The description could be pictorial, graphical, verbal, or kinesthetic.
- Give students observations of one aspect of the study site (such as the air temperature) from two or three months of the year (such as November and December) and ask them to predict what the observation would be like in the month following and preceding the observed months (October and January). This asks them to be able to identify a trend and its direction.
- Give students the observations from a "mystery month" and ask them to tell what month they think it was and why. If it is too difficult to pinpoint the exact month, ask them to identify the season in which they think the observation was made.

Extensions

- If students are comfortable with graphical representation of data, they can create graphs showing certain study site conditions. Current temperature and precipitation would be particularly appropriate.
- Contact another GLOBE school using GLOBEMail and share your observations with them. Ask them to send you their observations at their study site. Look at their observations and try to predict how their site will change at the next observation. Compare your prediction with what they send you next.
- Investigate how seasons are portrayed in art, literature, and history. How, for example, were the seasons expressed in painting by the French Impressionists? How have seasons affected the outcomes of military battles, such as the siege of Leningrad? How are seasons portrayed in Shakespeare's plays and poetry? How did Thoreau describe the seasons in *Walden*? How are the seasons described in the *Little House on the Prairie* series of books?

What Are Some Factors That Affect Seasonal Patterns?

Purpose

Students use GLOBE data and graphing tools to compare the influence of latitude, elevation, and geography on seasonal patterns.

Overview

Students analyze the graph of the past year's maximum and minimum temperatures at their site. They compare this graph to similar graphs for two other sites - one nearby and one distant. They list factors that might cause the patterns to be different, and select one to investigate in depth. They repeat this process with other parameters. Students summarize their investigations by describing how latitude, geography and elevation influence seasonal patterns.

Time

(assuming 45 minute classes)

Day 1	Steps 1-3
Day 2	Steps 4 and 5
Day 3	Steps 6-9
Days 4 and 5	Steps 10 and 12
Extension	Step 11

Level

Intermediate and Advanced

Key Concepts

Seasonal patterns are influenced by a combination of latitude, elevation and geography.

The annual patterns of the parameters measured in GLOBE are interrelated.

Skills

Graphing GLOBE data to show seasonal patterns

Comparing graphs and *analyzing* data to determine the effects of latitude, elevation and geographical features

Generating questions and *developing* hypotheses

Designing and *conducting* an investigation

Drawing conclusions about which factors can influence seasonal patterns

Communicating conclusions to others

Materials and Tools

Wall map of the world, if computers are unavailable or limited in number, print outs of the graphs in Steps 1, 4 and 6

Computer and the GLOBE Student Server

GLOBE Science Notebooks

Prerequisites

Students should understand that insolation levels vary with latitude, and that latitude has a powerful influence in determining seasonal conditions and the annual patterns of environmental and climatic parameters such as precipitation and temperature. For a more complete discussion, read *Why Are There Seasons?* in the Seasons Introduction.

Procedure

Step 1: Using the GLOBE graphing tool, have students plot the past year's maximum and minimum temperatures for their site on a single graph. See Figure SE-L-1.

Note: If your school is a new GLOBE site with little data, see *Finding a Nearby GLOBE School* or *Finding GLOBE Sites With Many Reported Measurements* in the appendix to find a nearby GLOBE site whose data you can use when you need long-term data for your area. Also, see *Using the GLOBE Graphing Tool* in the *Toolkit*.

Figure SE-L-1: The plot of a GLOBE site's maximum and minimum temperature data generated by the graphing tool

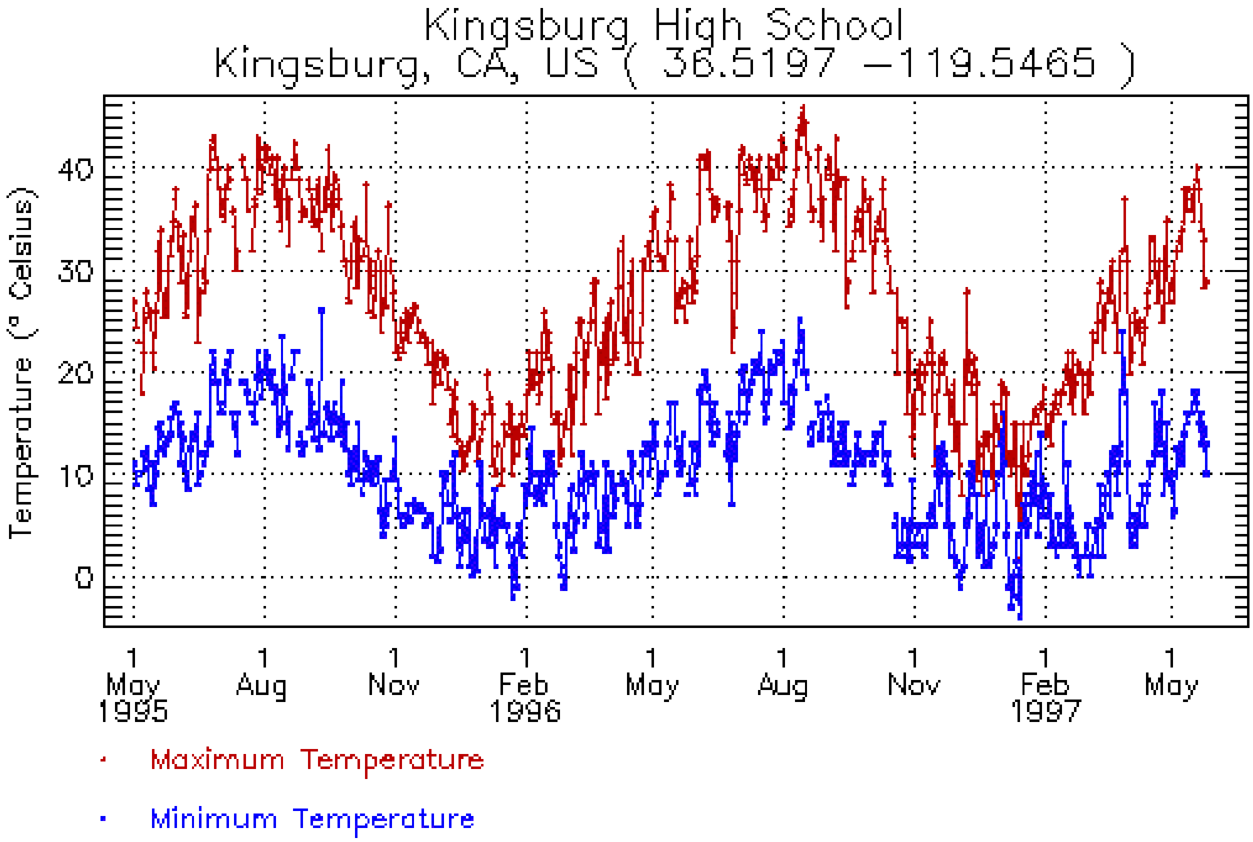
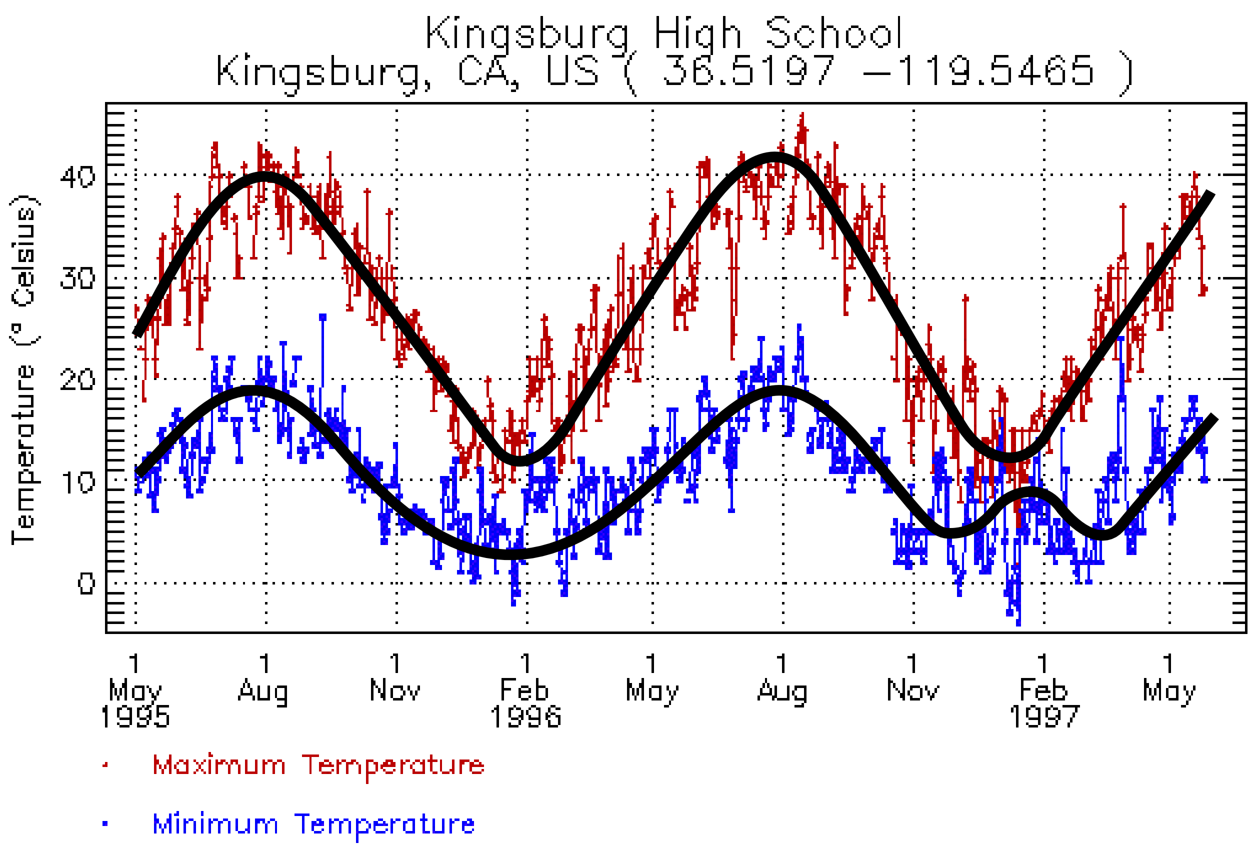


Figure SE-L-2: Two "average lines" drawn through a plot of a GLOBE site's maximum and minimum measurements.



Step 2: To highlight the general temperature trends, have students use one of the following ways to draw a line through the middle of the plot of the maximum and minimum temperature measurements.

a) have each student draw the lines directly on a copy of the graph.

b) have students lay a clear sheet of acetate over a copy of the graph and draw the lines onto the acetate with overhead markers.

Note: Because temperatures can fluctuate dramatically from day to day, a plot of daily temperatures can look very jagged. Furthermore, since the GLOBE graphing tool connects each data point with a line, the resulting graph has a great deal of "noise," marks that add little real information. In most cases, however, it is the long-term trends that enable students to make the most meaningful comparisons. By eyeballing a line through the center of each plot, students can determine a rough average for each set of measurements and highlight the long-term trends. See Figure SE-L-2.

Once students draw an "average line," they can superimpose it on other "average lines." For example, students can superimpose an "average line" of the minimum temperatures at their site onto the plot of their site's maximum temperatures to see if both temperatures rise and fall in the same way. Also, students can examine temperature patterns from different years by superimposing the "average lines" of the maximum and minimum temperatures from one year on a similar graph from another year. Students can also see how trends at different sites compare by superimposing the "average lines" from one site onto the plot of the temperatures at another site.

Step 3: Have students analyze the graph of these data by considering questions such as:

- What is the general shape of the average line?
- What does the shape of the average line enable us to say about our site?
- What is the approximate difference between the daily maximum and minimum temperatures throughout the year? How does this difference vary over the year?

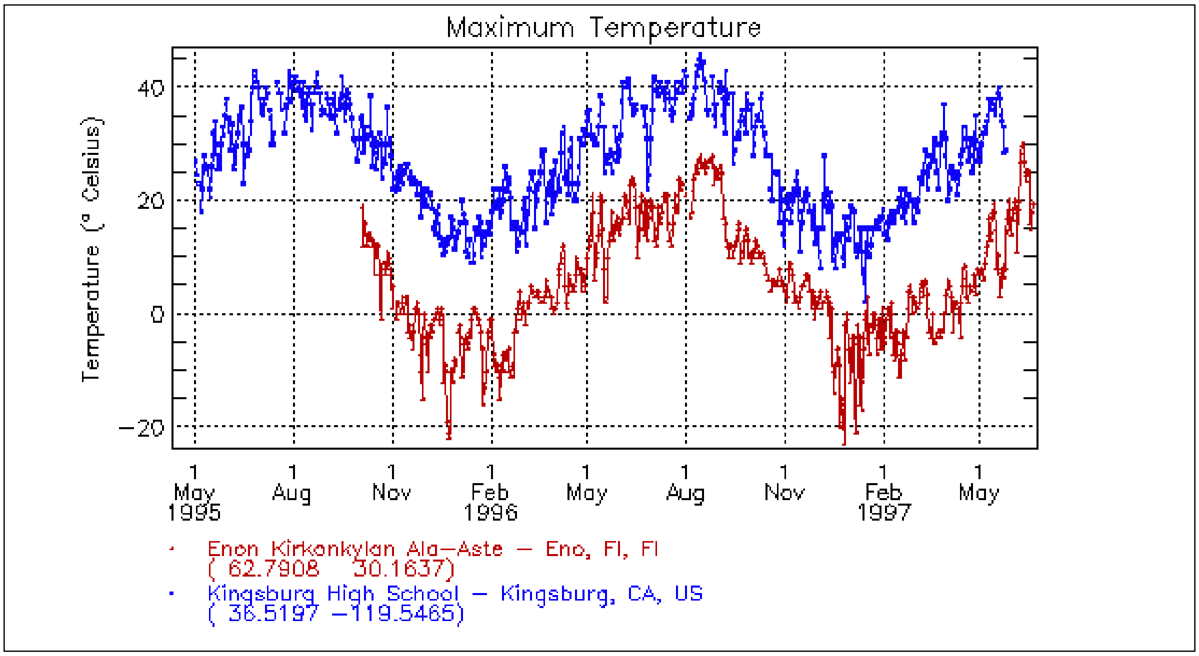
Note: This analysis can be conducted as a class discussion. If the graph is printed for each student, it can also be done in small groups or assigned as homework. Have students copy or paste the graph into their GLOBE Science Notebooks and record their analysis and any questions that arise.

Step 4: Have students find another GLOBE school about 100 km away and repeat Steps 1-3 for this school.

Note: This step asks students to find a school at approximately the same latitude as theirs (100 km north or south is roughly equivalent to 1° of latitude). Climatic changes happen gradually unless there is some dramatic elevation or geographic change over a short distance. As a result, by analyzing the data from a nearby school, students are likely to see similar temperature patterns. When there are differences, their knowledge of the local geography should help them pinpoint reasons for the differences such as one site is coastal and the other is inland, one site is at a higher elevation than the other, or one site is behind a mountain range.

This step builds students' graph-analysis skills by having them compare graphs with only a few significant differences. Also, because they are familiar with the local geography, this step increases the likelihood that students will identify key factors that influence temperature patterns. By pre-

Figure SE-L-3: The maximum temperature plot from GLOBE sites in Finland and California generated by the graphing tool. Note that the California site has reported data over a longer time period.



selecting a nearby site with sufficient data, you can greatly expedite this step. See *Finding a Nearby GLOBE School* and *Finding GLOBE Sites With Many Reported Measurements* in the *Appendix* and *Using the GLOBE Graphing Tool* in the *Toolkit.*

Step 5: Have students describe how the temperature patterns at the nearby site are similar to and different from theirs. For each difference they observe, have students suggest reasons that might explain such variations. After students work together in small groups, conduct a class discussion that summarizes the comparison. Possible points of comparison include:

- How does the timing of the year's maximum and minimum temperatures compare?
- How does the spread between daily maximum and minimum temperatures compare?
- How do the general shapes of the graph lines on the two graphs compare?
- What conclusions about seasons can be drawn based on the temperature patterns at these two sites?
- Do the temperature levels change similarly after the solstices and equinoxes?

Note: To facilitate comparisons, the graphing tool can be used to plot one parameter such as maximum temperature for two sites. See Figure SE-L-3. If graphs are printed for each student, this step could be done in small groups or assigned as homework. Have students sketch or attach print outs of the two graphs and record their analysis and any questions that arise in their GLOBE Science Notebooks.

Step 6: Have students choose another GLOBE site at least 1000 km away that is likely to be climatically different. Have them repeat Steps 1-5

Note: The intention of this step is to find a GLOBE site with an annual temperature pattern quite different from the two already considered. The analysis could be assigned as homework.

Step 7: Have students list factors that might cause the patterns to be different.

Note: Use a wall map of the world or the maps found under GLOBE Visualization to focus attention on differences in latitude and elevation, and in proximity to oceans and other significant geographic features. Have students record the factors and any questions that arise in their GLOBE Science Notebooks.

Step 8: Since every site has a combination of factors, conduct a class discussion based on the Venn diagram below. See Figure SE-L-4. In their GLOBE Science Notebooks, have students write a general statement about how latitude, elevation and geography influence their local temperature patterns.

Note: Students should understand that it is important to know a site's latitude, elevation and geography before drawing conclusions about its temperature patterns.

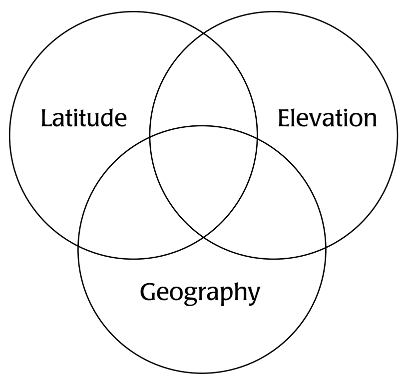


Figure SE-L-4: Every site has a combination of factors that influences the annual patterns of its parameters

Step 9: Ask each group to select one of the factors that might account for temperature pattern differences between the distant site and theirs. Have group members write a plan for investigating this factor, including how to use GLOBE data to test their hypotheses. For example:

Elevation: Compare the annual temperature patterns of sites at different elevations.

Latitude: Compare the annual temperature patterns of sites at different latitudes.

Coastal versus Inland: Compare the annual temperature patterns of sites at different distances from oceans — where do the effects of a marine climate end? They might also compare the marine effect along different coasts.

Note: Different coasts can have different marine effects. For example, the Atlantic and Pacific coasts of the U.S. have different current patterns and prevailing winds that result in different kinds of marine climates. However, both these marine climates moderate temperature extremes and provide considerable moisture to the air.

Additional Factors: Many parts of the world have factors that pertain only to a local region. For example, students could compare sites near to and far from the Gulf Stream, the Santa Anna winds, the Sahara Desert, the Amazon basin, coastal mountain chains, rain shadows, and prairies. Also, they could investigate what kind of influence the size of a continent and the direction of the prevailing winds can have.

Note: To confirm an influence, students will have to keep all other factors constant. For example, to see if elevation has an effect, students must find sites that differ in elevation but have similar coastal-continental locations, latitudes, and proximity to significant geographical features. If the only difference in the sites is elevation, then any differences in temperature patterns can be ascribed to elevation. To bolster confidence in any pattern they find, students will also need to use data from several sites and from a significant time period (e.g., a year). An effect seen by comparing data from only two sites or from a single day is vulnerable to errors and short-term changes and is very unreliable. Have students record their hypotheses and procedure in their GLOBE Science Notebooks.

Step 10: Have students follow their plan and summarize any effects they discover.

Note: Have students record their data, analysis and conclusions in their GLOBE Science Notebooks. They can share their investigation, conclusions and further questions with another school (such as the ones selected for comparison) using GLOBEMail.

Step 11: To further investigate how these factors influence seasonal patterns, have students repeat Steps 1-10 using precipitation and any other parameters they deem important in characterizing a season.

Note: For a mini-investigation in how to determine whether one parameter such as temperature influences another such as precipitation, see "How Can One Tell Whether Two Parameters Are Interrelated?" in the appendix.

Step 12: In their GLOBE Science Notebooks, have students write statements about:

a) how latitude, elevation and geography influence the seasonal patterns of the parameters measured in the GLOBE program; and

b) how the annual patterns of the parameters measured in GLOBE are interrelated.

Assessment

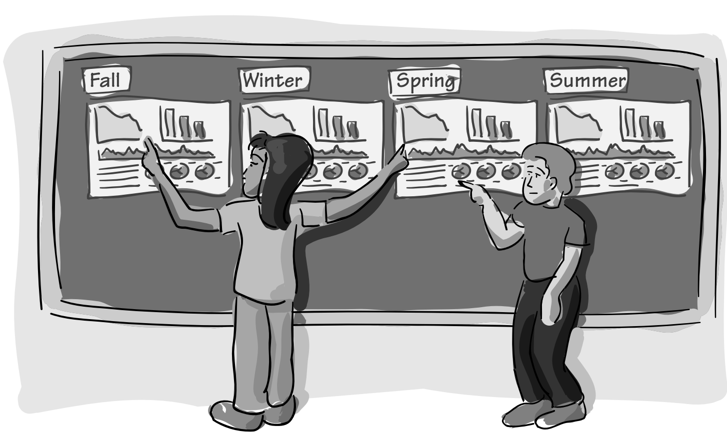
By the end of this activity, students should be able to use graphs and data to support the claim that seasonal patterns are influenced by a combination of latitude, elevation and geography.

All levels:

Poster reports, papers, and multi-media and oral presentations require that students organize and prioritize their thoughts and present their understanding coherently. Consequently, they are effective techniques for assessing students' mastery of concepts, skills and processes. The quality of the information recorded in their notebooks is also an important component in assessing students' ability to communicate their science. Examine their notebook entries, and have them use their GLOBE Science Notebooks to develop their reports and presentations.

Have students demonstrate their understanding of how latitude, elevation and geography influence seasonal patterns by having them respond to questions such as:

- Why are patterns at our site so similar to those at the site 100 km away?
- Why are there such differences between our site and the one 1000 km away?
- What factor(s) did you investigate, how did you do it and what did you conclude?
- Discuss how latitude, elevation and geography influence each parameter measured in GLOBE.
- What are some geographical features that influence seasonal patterns in our area? Describe how they influence the patterns and use data to support your claim.
- How can there be distant sites that experience patterns similar to ours while at the same time there are other distant sites that experience patterns different from ours?



- When considering latitude, elevation and geography, does one seem to be more important than the others in determining local seasonal patterns?
- What would you want to know about a site before commenting on its seasonal patterns? Explain why such information is important.
- Why is temperature alone a poor indicator of a season?

  Note: Temperature is variable over the short term and is influenced by other variables such as latitude, elevation and geography. For example, summer at the poles can still be cold and spring at the base of a mountain is different from spring at its summit. One needs to know a location's latitude, elevation and geography to understand the seasonal patterns.

Advanced:

- How would the graphs of a site change were it moved to a different latitude, elevation or geographical setting?
- Provide students a graph of an annual pattern that is inconsistent with that pattern at their site. Students should be able to identify specific ways the "mystery" pattern is different from theirs.

  Note: You could draw a hypothetical pattern or use one from another site.
- How do seasonal fluctuations relate to the timing of the solstices? Equinoxes? How soon after the solstices do changes begin to occur? Is the lag time the same for each season? For each solstice?

  Note: Temperature levels are influenced by the energy available from the sun. Because the solstices are the dates that correspond with insolation extremes in the temperate and polar zones, the solstices represent points in a temperature's annual cycle in these zones. However, it takes time for the atmospheric temperatures to respond to these insolation extremes, so there is a lag time of several weeks before the new levels of insolation have a significant affect on temperature. In this activity, students will discover lag times as they check whether temperature levels in the temperate and tropical zones change on the date of the solstices. Because sites have different latitudes, elevations and geographical settings, different sites will have different lag times. Note that on the equinoxes, the sun is directly over the equator. Consequently, the equinoxes represent the insolation extremes in the tropical zone.

How Do Seasonal Temperature Patterns Vary Among Different Regions of the World?

Purpose

Students use GLOBE visualizations to display student data on maps and to learn about seasonal changes in regional and global temperature patterns.

Overview

Students use the GLOBE Student Data Archive and visualizations to display current temperatures on a map of the world. They explore the patterns in the temperature map, looking especially for differences between the Northern and Southern Hemispheres, and between equatorial regions and high latitudes. Then students zoom in for a closer look at a region which has a high density of student reporting stations (such as US and Europe). They examine temperature maps for the region, from four dates during the past year (the solstices and equinoxes). Students compare and contrast the patterns in these maps, looking especially for seasonal patterns. At the end of the activity, students discuss the relative merits of different types of data displays: data tables, graphs and maps.

Time

Approximately three class periods

Level

Grades 3-12

Key Concepts

Temperatures vary from one location to another around the world.

Global temperatures patterns vary from one season to the next.

Local latitude, elevation and geography affect seasonal temperature patterns.

Current weather conditions affect regional and global temperature patterns.

Skills

Mapping data with the GLOBE Student Data Server to explore seasonal temperature patterns

Comparing graphs, maps and data tables as tools for data analysis

Materials and Tools

Access to the GLOBE Data Server

A map of the world

Acetate and markers (optional, so students won't mark directly on maps)

Preparation

You may want to display, print and make copies of the maps before class.

Prerequisites

We recommend that students first do *What Are Some Factors That Affect Seasonal Patterns?*, so that they have experience with using graphs to explore seasonal changes in data from individual schools, and so that students have a basic understanding of factors affecting seasonal changes in temperature.

Background

In this activity, your students use GLOBE's visualization tools to explore seasonal patterns in global and regional temperature data. This serves two purposes. First, students learn about seasons in a global context. Second, students learn how to use GLOBE's mapping tool to see global patterns in GLOBE student data.

Special Note: Some regions do not yet have enough reporting stations for thorough analysis.

For the time being, there are regions of the world (such as the United States and Europe) which have large numbers of schools reporting data, whereas other regions have fewer stations. Therefore, when you look at GLOBE visualizations, you will find some areas of the world with ample data for the types of analyses described here, whereas other areas may be too sparse for adequate analysis. Recognizing this temporary constraint, this activity includes both global studies (using the full scope of GLOBE reporting schools) and regional studies (which focus on areas with many reporting sites). Eventually, as GLOBE grows, your students will be able to do more and more global studies.

Mapping Data with the GLOBE Visualization Tool

Please refer to the color maps displayed in Figure SE-L-10 through SE-L-17. GLOBE's visualizations display student data in maps. These visualizations are especially powerful tools, and can be used to help students conduct a variety of investigations. In essence, you select the region that you want displayed, the type of data, and a date and time. Then the GLOBE software creates the requested map, and sends it to you over the Internet.

There are two types of maps that can be displayed: dot maps and contour maps

Figure SE-L-10 is a dot map. This shows each reporting school as a colored dot. The color of the dot corresponds to the value reported by the school. This type of map is best when you want to know where the reporting schools are located, and get a sense of the individual data values (as represented by the color).

Figure SE-L-11 is a contour map. This map uses the raw data to create contours, such as the temperature bands in the example. This type of map is best when you want to explore patterns in the data. You can use the color key to find out what values are indicated by each band. Also, there may be regions of the map without contours. These are areas in which there are no reporting stations.

For these activities, we recommend contour maps because we are more interested in the patterns than in the actual values. Your students will focus primarily on the shape of the temperature bands (noting, for example, where a given band dips down toward the equator).

Your students may quickly learn how to work with contours, since these are the same types of temperature maps that appear in newspapers and on TV, and appear in science textbooks. If your students are confused, you might want to have them work with a data map to make their own contour map. First, use crayons to circle all the points in each temperature range (for example, use red to circle all points with a temperature of 20-29, blue for temperatures 30-35, etc.). Then have your students use crayons to draw bands connecting the points that are the same color.

Temperatures Vary from One Location to Another Around the World

Your students begin by displaying current temperatures, as reported by students around the world. For example Figure SE-L-12 shows a map of student data from all currently reporting schools. In the activity, you will have students explore the map, looking for global patterns. In this example, notice that:

1. There are gaps in the data, because some parts of the world do not yet have GLOBE schools. The world coverage will improve over the years.
2. Since the data are from December, the Northern Hemisphere is generally cooler than the southern hemisphere
3. There are variations in the temperature patterns based on current weather and

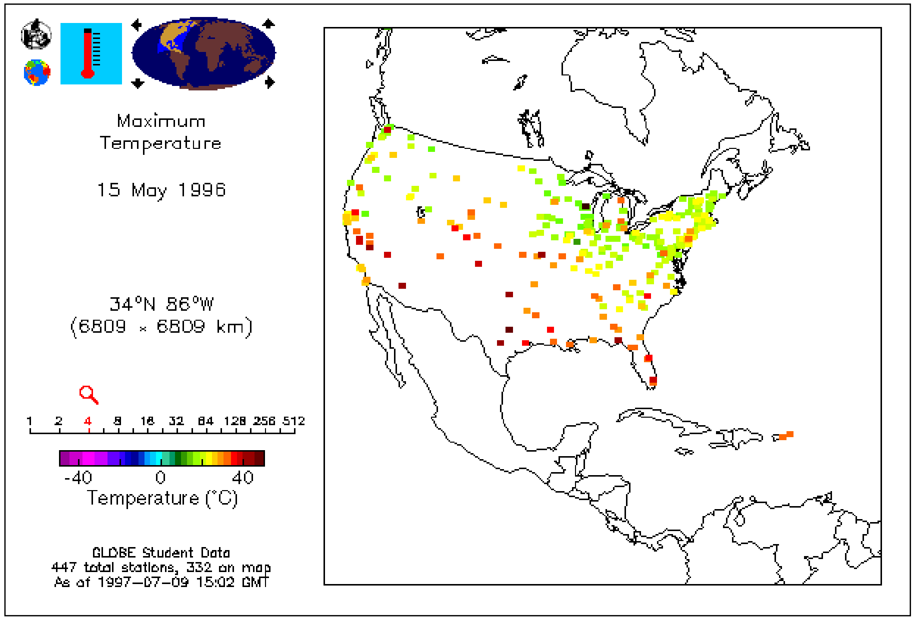


Figure SE-L-10: GLOBE Dot Map of Maximum Temperatures in the U.S., on May 15, 1997

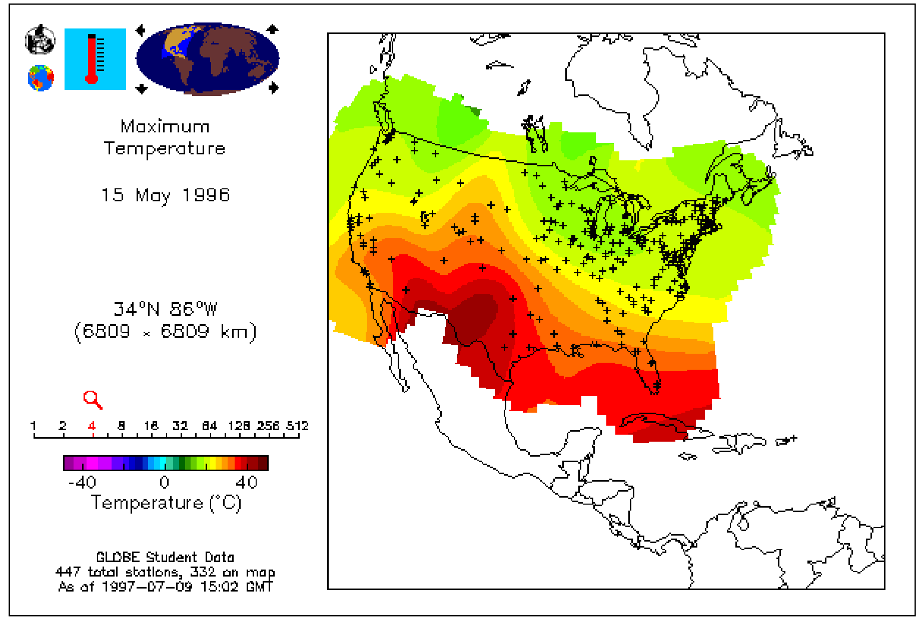


Figure SE-L-11: Same GLOBE Data as a Contour Map

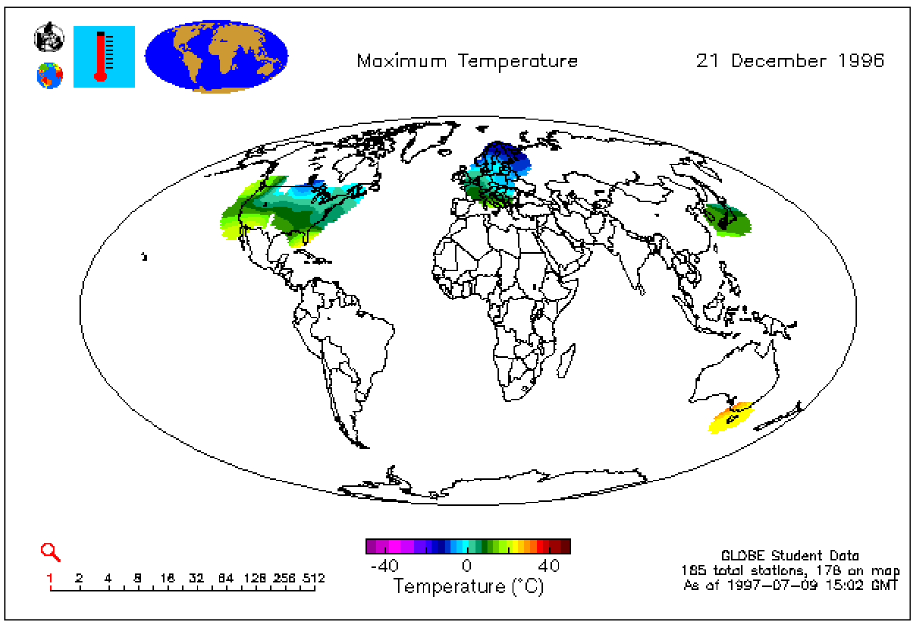


Figure SE-L-12: World Temperature Patterns on December 21, 1996 (These maps will become more complete as additional GLOBE Schools begin submitting data.)

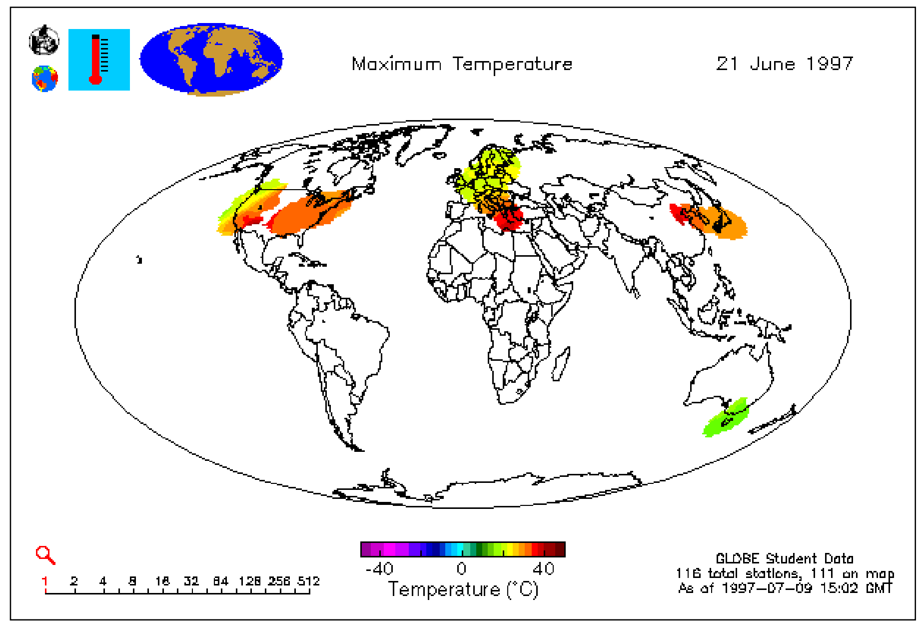


Figure SE-L-13: World Temperature Patterns on June 21, 1997

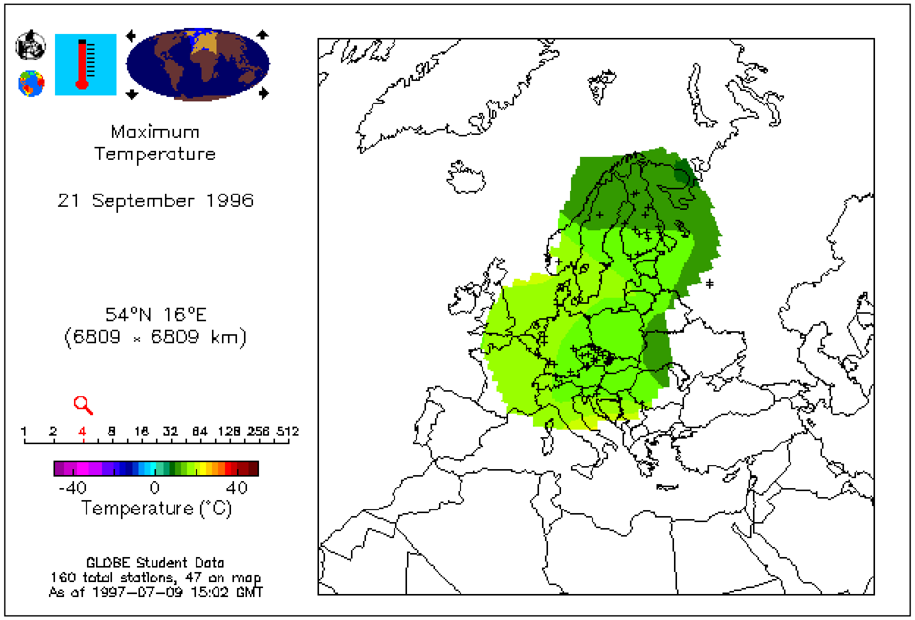


Figure SE-L-14: Europe Temperatures in the Fall - September 21, 1996.

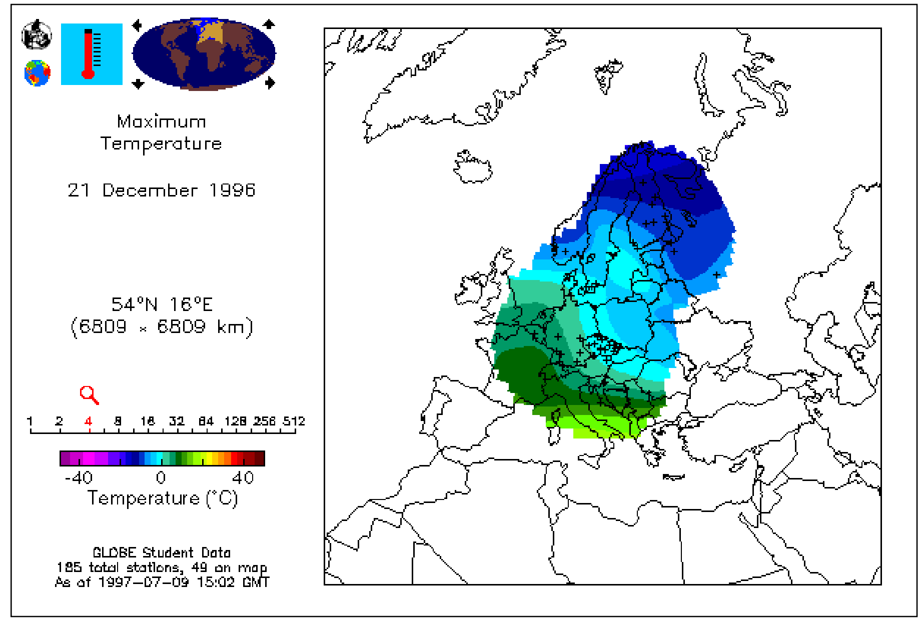


Figure SE-L-15: Europe Temperatures in the Winter- December 21, 1996.

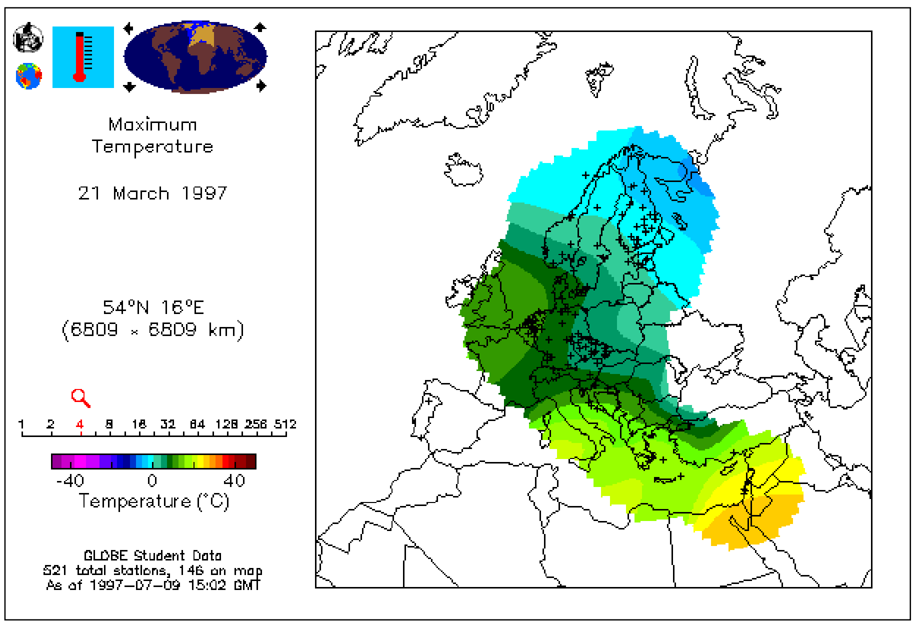


Figure SE-L-16: Europe Temperatures in the Spring - March 21, 1996.

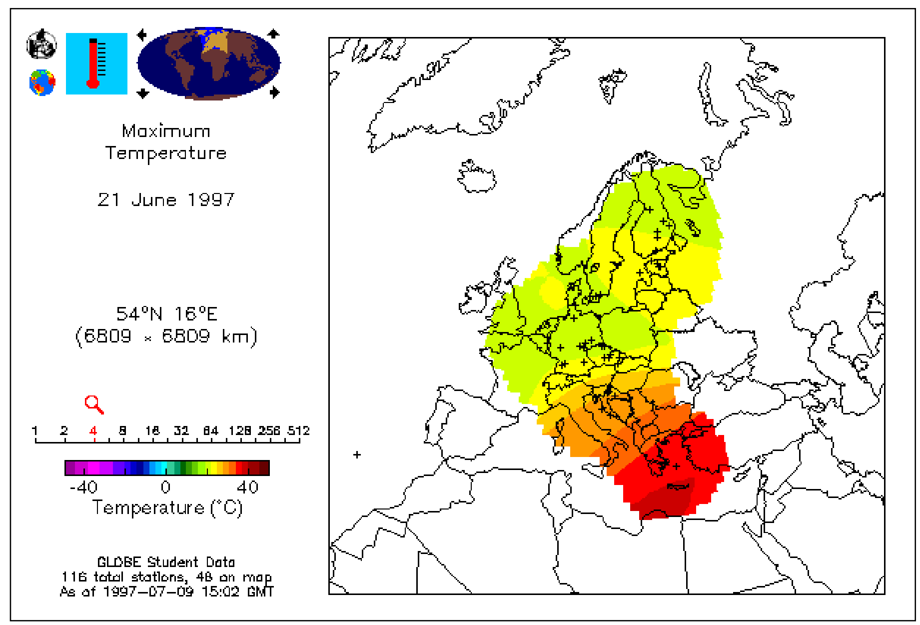


Figure SE-L-17: Europe Temperatures in the Summer - June 21, 1996.

local climatology (e.g. France is warmer than Northeastern U.S., even though they are both at the same latitude)

Temperature Patterns Vary from One Season to the Next

When your students display temperature maps from four different days throughout the year, they are able to explore the seasonal variations in global temperatures, as shown in the above sample maps. (For more detailed analysis, your students could display data from each month of the year).

In these sample maps, Figures SE-L-14 through SE-L-17, notice that:

1. It is generally warmer in the summer and colder in the winter.
2. Fall and spring are similar in temperature.
3. Regardless of season, it is warmer the farther south you look.

Regional Maps Show Greater Detail in the Temperature Patterns

When you zoom in for a closer look at a region of the world, you can see more detail. This enables you to see regional patterns more clearly. In Figure SE-L-14 through SE-L-17, you can see the differences among four different views, each representing a different season. For example:

1. Temperatures are generally warmer in the summer than the winter.
2. Weather patterns are not constant throughout the year (for example, the curves in the temperature contour on June 21 is not the same as on Sept. 21).

Your students can extend the investigation by looking at seasonal variations in other types of data, such as precipitation type and amount, soil moisture or water temperature. Your students can also explore how the local variations are affected by local geography and elevation.

What To Do and How To Do It

Note: These activities work best if students gather around the computer or take turns, so that they can work directly with the GLOBE visualizations. Or you can print the GLOBE maps and make copies for each student or for groups of students.

Step 1: Display a map of recent temperatures world-wide.

Use the GLOBE data system to access recent temperature data (either minimums or maximums) from all student sites around the world, and display the data on two types of maps: data map and contour map. You might want to choose yesterday's data, since some schools may not yet have reported today's data.

Step 2: Students explore the global temperature maps.

Begin with the dot map. Have your students examine the map. First look for your own site. This shows the temperature data reported by your school. It is shown as a colored dot, with the color corresponding to the temperature. Next, look for other sites, and compare their location and temperature with your own. Find other schools with the same temperature (color) as your own. Find other schools in your own country. Find a school in each continent. Then find the absolute warmest location, and the absolute coldest location.

As noted in the background section, you will see that some areas have many GLOBE schools reporting data, and other areas have few or none. As more schools begin reporting data, your students will be better able to see global patterns. You can use this opportunity to help your students see the importance of having many schools world-wide and having each report their data every day.

Next, have your students look for global patterns in the temperature data. Your students might notice that:

1. Temperatures are warmer in equatorial regions, and colder as one moves further north or south.
2. The Northern Hemisphere is warmer than the Southern Hemisphere or vice-versa.

Step 3: Students zoom in for a local view, and explore regional seasonal variations.

Ask your students what they think the global temperature map will look like at different times of the year. This can be a useful discussion, helping students to think about global seasonal patterns, and to make their own predictions. It also helps you as teacher to find out what your students know and what misperceptions they might have.

Tell your students that they will now zoom in for a closer view of one or more regions of the world. Have them select areas of the world where there are many data points, and then request a contour map for that region. Make sure your students understand what the contour map shows (same data as in the data map, but presented as temperature bands). Ask them what shapes and patterns they see in the contour map.

Now select maps of the same region, from four different dates during the year. This will enable them to examine how the temperature patterns change over the year. Ask your students what four days would give a good cross-section of the year. Discuss your students' suggestions. Either proceed with whatever dates they suggest, or guide the discussion to selecting the four seasonal transition points (June 21, Sept. 21, Dec 21, Mar 21). You might want to discuss the significance of these dates (solstices and equinoxes). Another approach is to select 12 dates, one per month. This will give your students more detail in the year-long variations.

Access, display (and if possible print and make copies of) the temperature map for each of the four days.

Now have your students study the maps. What similarities do they see from one season to the next? What differences? You want to promote student inquiry and investigation here, so don't simply tell them what the patterns are, but let your students explore the maps and discuss individually or in small groups.

Discuss what they found. They are likely to see:

1. One season tends to be warmer than another.
2. Regardless of season, it tends to be warmer as one moves closer to the equator.
3. Weather patterns are not constant throughout the year. The shape of the temperature bands will vary from one day to the next.
4. If you look at schools in the same latitude, you will find differences in their temperatures.

Ask your students why these patterns occur. For example, they may understand that the northern and southern hemispheres have opposite seasons. Or they may comment that local weather conditions impact on the seasonal variations (coastal regions tend to have more stable temperatures throughout the year.)

Step 4: Students compare and contrast data tables, maps and graphs. See Figure SE-L-18 through SE-L-20.

In this activity your students use GLOBE maps. In other activities, students use graphs and in others they use data tables. These three types of data displays enable your students to visualize, understand and interpret the data. At this point, it is worth exploring with your students the merits and applications of these three types of data displays.

Show your students these three types of data displays. Ask your students what type of information they see in each display. Then discuss with your students the advantages and disadvantages of each type of display.

For example, your students might notice that:

Maps show how data varies from one location to another. You can see world-wide or regional patterns such as the warmer temperatures in the equatorial regions of the world.

Graphs show how data changes over time. You can see annual patterns such as the warmer temperatures in summer and the colder temperatures in winter.

Data tables show lots of data values in a grid. You can quickly find any type of data for any location, such as the temperature and precipitation amount for a given city.

Post a copy of the map, graph and data table on

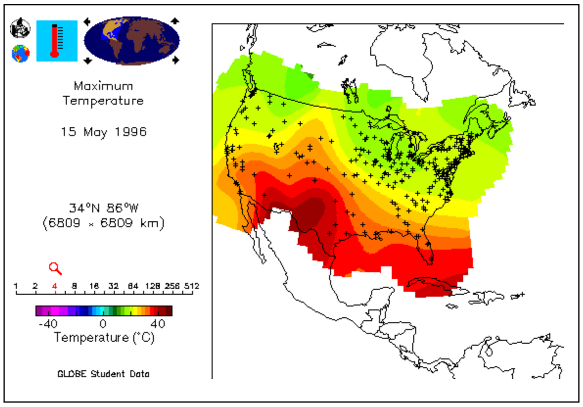


Figure SE-L-18: Maps

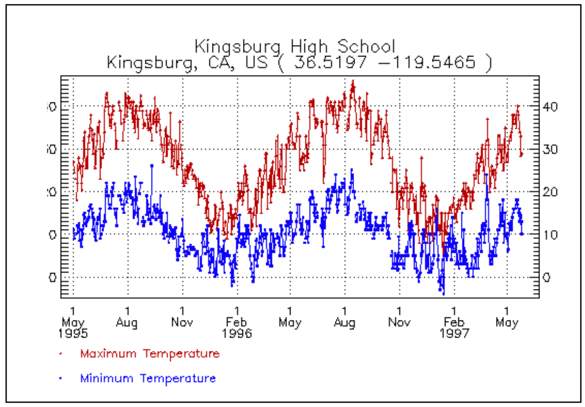


Figure SE-L-19: Graphs

Data for 19970707 to 19970707

Atmospheric Temperature						TEMPERATURE		
MG	YY/MM/DD	HR	LAT	LONG	ELE	CURR	MAX	MIN
AT	97/07/07	20	47.6589	-117.4250	675	24.0	34.0	12.0
AT	97/07/07	19	32.2217	-110.9258	836	36.1	41.7	25.6
AT	97/07/07	19	36.5197	-119.5463	27	34.0	39.0	17.0
AT	97/07/07	19	33.7769	-118.0386	7	24.0	24.5	17.0
AT	97/07/07	19	45.4556	-112.1961	1594	29.0	29.0	7.0
AT	97/07/07	18	33.7769	-118.0386	7	23.0	26.0	16.0
AT	97/07/07	18	40.7608	-111.8903	1711	29.0	34.0	16.0
AT	97/07/07	18	47.6064	-122.3308	67	21.0	-99.0	-99.0
AT	97/07/07	17	57.7883	-152.4030	35	12.0	15.0	11.0
AT	97/07/07	17	35.8422	-90.7042	69	31.0	31.5	17.5
AT	97/07/07	17	39.7683	-86.1581	259	28.0	-99.0	-99.0
AT	97/07/07	17	39.2403	-76.8397	57	30.0	-99.0	-99.0
AT	97/07/07	17	44.8817	-69.4458	88	28.0	30.0	7.5
AT	97/07/07	17	39.7558	-77.5782	375	27.0	27.0	16.0

Figure SE-L-20: Data Table

a bulletin board, and have your students write under each type of display some interesting observations that they see in that display. For example, under the graph they might write the coldest day of the year. Under the map, they might write the coldest location in the world. Then have them write some questions that could be answered with that type of display.

You may need to revisit this comparison of different types of data displays, as students plan their own investigations, such as in step 5 below. Students need to be sure that they're using the most appropriate display for their data analysis.

Step 5: Students use an inquiry-based approach to extend the investigations.

There are several ways that you and your students can extend the investigations. For example:

- Print out maps from two consecutive days (such as June 21 and June 22). Using these two maps, students can explore short term variations versus long-term seasonal changes. For example, they might see minor changes in the shapes of the temperature bands from one day to the next, and larger changes in the overall temperatures from one season to the next.
- Pick two locations for more detailed comparison. For example, your students might find that a town on the Mediterranean coast has less variation between winter and summer than a place in central Canada. This might be because the water of the Mediterranean has a moderating effect on temperature variations. If so, do other coastal locations have similarly moderated temperature variations?
- Display other data on the maps, such as precipitation amount. Students might compare patterns of snowfall in the winter versus the summer and compare northern hemisphere vs. southern hemisphere.

In each of these extensions, be sure your students use an inquiry-based approach, in which students:

1. Begin by exploring the displays to see what patterns and questions emerge.
2. Select a question that seems especially interesting.
3. Decide what resources can help students investigate the question. Especially focus on use of GLOBE data (each of the examples above uses GLOBE data).
4. Conduct the investigation, either individually or in teams.
5. Share the findings with other students.
6. Think about what new questions emerged that could lead to further investigations.

For these investigations to succeed, they need to be genuinely engaging for the students — in other words the student(s) should really care about the answer. One goal of the activities in this seasons module is to stimulate such interests. In that sense, these activities not only have their own intrinsic value, but also serve as launching pads for further investigations.

Assessment

In this activity, your students have learned about seasonal patterns in global temperature data. They also have learned about GLOBE's map visualization tools. To assess student learning, use the following two steps:

1. Ask your students to use the GLOBE data server to create a contour map of student temperature data from July 15 and January 15 (these dates are near the peaks of summer and winter, and are different from the maps they've already used). Check to make sure each student is able do this activity correctly. You might have a student who knows how to do this help you by observing the other students as they go through the steps, to see who knows how to do this, and who has what kinds of problems.
2. If possible print out the July 15 and January 15 maps from the previous step, and make copies for your students. If you can't do this, then use the sample Dec 21 and June 21 temperature maps that appear in the background section. Then have your students indicate which is summer and which is winter. If you wanted to extend the assessment further, you might print out a 6 month sequence from July 15 to January 15 (one map from each month), cut out or cover over the date on each display, and then ask your students to sort them into the proper sequence. Then ask them to write down what evidence they used to put them in this sequence.

What Can We Learn by Sharing Local Seasonal Markers with Other Schools Around the World?

Purpose

This activity promotes collaborations among teachers during and after the GLOBE teacher training program. It helps teachers and students learn how to work with the GLOBE data system and GLOBEMail email. It also helps teachers and students learn how the protocols are interconnected and can support inquiry-based investigations.

Overview

The central topic of this activity is seasonal markers, which are the various biological, physical and cultural changes which mark transition points in the annual cycles of seasons. Examples are the first snowfall, the beginning of monsoon rains, and the summer solstice. Teachers begin this activity in the GLOBE teacher training workshop by discussing the differences in seasonal patterns among their respective communities. Then the teachers agree on a list of 5 seasonal markers which they would like the teachers and their students to observe in their own communities. When teachers return to their schools, they engage their students in the activity, and use GLOBEMail over the next several months to share the seasonal marker observations. By comparing GLOBE data with the shared seasonal marker information, students are able to conduct their own collaborative investigations of seasonal patterns. The collaboration also promotes on-going collegial support among the teachers to help each other in implementing the full GLOBE Program.

Time

One hour and a half in the GLOBE Teacher Training Workshop.

About 15 minutes per week over the next several weeks.

Level

Teachers and students at all levels

Key Concepts

Seasonal patterns, with a special focus on seasonal markers

Skills

Communicating data and comments using GLOBEMail

Exploring seasonal patterns in the GLOBE Student Data Archive

Collaborating with other GLOBE schools

Materials and Tools

Access to GLOBEMail

World maps (black and white line master on 8 1/2 x 11 sheet) - one per participant

Preparation

Teachers begin this activity at the workshop, then continue it with their students

Prerequisites

Teachers need to attend the GLOBE Teacher Training Workshop, during which this activity is launched.

Background

Seasonal markers are indicators of seasonal change. For example, the first appearance of a particular migrating bird, such as a robin, is a classic marker of spring. Examples of other markers are ice melting on lakes, the thawing of soil, emerging leaves on trees, and warming temperatures. Notice that in this list there are examples relating to hydrology, soil, biology and atmosphere. In this activity, you learn more about seasonal markers and begin to share observations of markers with your teacher colleagues..

You will use GLOBEMail to communicate with other schools. GLOBEMail is an electronic mail system, in which you can write letters and send them by email to other teachers and students. GLOBEMail is different from the GLOBE data system in which you send the data values from the GLOBE protocols. Rather, GLOBEMail enables you to go beyond the raw data, and have more open-ended communications, to share ideas, to reflect on your experiences teaching GLOBE, and to help other teachers as you work through some of the challenges of implementing GLOBE. Such collegial support can be a real help to you as you begin to implement GLOBE. For your students, GLOBEMail enables them to work collaboratively on investigations with other students throughout the world.

Seasonal markers are not a standard GLOBE protocol and are not part of the GLOBE data system. Therefore, you and your students will use GLOBEMail as an informal way to share the seasonal marker observations. As shown in the example below, you simply enter the marker observation as a comment in the GLOBEMail message. Be sure to describe the marker and include the data. It also helps to add a personal note that might make the observation more interesting or informative.

These GLOBEMail messages also provide the opportunity for you to share other comments about your experiences teaching GLOBE. You know the teachers who will receive this message, since they were your colleagues in the GLOBE Teacher Training Workshop. Therefore, they are likely to be interested and perhaps helpful in their response to your GLOBEMail messages. Your students can also use GLOBEMail to share ideas for and results of collaborative investigations.

GLOBEMail

To: Seasonal Markers Team

From: *School name*

Today (Nov 13) was the first snowfall. It was only a dusting, but this is the earliest we've ever had snow.

Incidentally, we have just begun to use the data server to explore plotting data on graphs. We were surprised by some abnormal "blips" in the local temperature graph. When we investigated this, we found out that a student had entered Fahrenheit temperature instead of Celsius. So, we suggest graphing your data as a way to find errors in your data.

What To Do and How To Do It

Phase 1 – During the GLOBE Teacher Training Workshop

Step 1: Workshop leader explains the purpose

The workshop leader introduces this activity, explaining that this activity has three goals. First, it helps teachers understand the GLOBE seasons module. Second, it helps teachers stay in contact and help each other after the GLOBE Teacher Training Workshop. Third it provides an interesting seasons investigation for your students.

Through this activity, students and teachers share detailed observations of seasonal changes in their local communities, and work together to investigate regional patterns in the seasonal changes. Teachers in previous workshops have requested a way to maintain contact with their new GLOBE colleagues, to help each other implement GLOBE, and to participate in a collaborative investigation using GLOBE data.

Step 2: Groups of teachers discuss seasonal variations

Form groups of about 10 teachers. Distribute world maps, one per teacher. (If all teachers are from a single country or region of the world, it might make more sense to use a regional map.) On the maps, each group plots where each teacher is from. Write the name of the teacher and the town on the map.

Then discuss the differences in seasons among the different locations. For example, some schools might have snow for several months in the year, others might have none. Try to discuss both qualitative and quantitative differences, including when the seasonal changes generally occur. This discussion is richer if there are teachers from many parts of the world. If you don't have such broad geographical diversity, you might spend some time in the discussion speculating on seasonal variations in other parts of the world.

Step 3: Groups of teachers discuss seasonal markers

Next each group discusses seasonal markers. The workshop leader should make sure everyone understands what seasonal markers are (refer to background). Each group brainstorms a list of seasonal markers that might be observed at different times by the different teachers in the group. For each marker, indicate which season it is associated with. (Equatorial regions should use local definitions of seasons such as dry and monsoon.)

Here are some markers that the teachers might identify:

bird migrations	first snow
lake freezes	first crocuses
monsoon rains	startwhale migrations
bud break	leaves begin fall colors
mosquitoes	butterfly migration
bull frogs croaking	first tomatoes
first frost	first day w/no coat
heavy pollen	

Step 4: Select which markers to investigate

Bring all the groups together and have each group describe their markers out loud. Then have the full group select five markers which a) all or most of the teachers will be able to observe, b) occur over the next four months, and c) are likely to show variation from one school to another. (The number of markers and the length of time are reasonable figures, but the group may decide on other values.) Make sure each teacher has a list of the selected markers.

Step 5: Workshop leader explains what happens after the workshop

The workshop leader explains that all teachers (with the help of their students) will watch for the occurrences of the seasonal markers, over the next several months. As detailed below, students and teachers will:

- share their observations of the seasonal marker events with the other teachers
- investigate the data from these observations and share their own analyses of the patterns in the seasonal markers
- help each other by sharing their experiences implementing GLOBE
- work together on collaborative investigations with students from other GLOBE schools

Make sure the teachers understand the purpose and nature of this follow-up activity. You should also check on the degree of expected participation. Some teachers may be quite interested in this investigation, and others may not. Among the interested teachers, divide the full group into smaller groups of about ten teachers (more teachers could be overwhelming in terms of the total email). The teachers should also decide if they want to begin right away, or whether they want to wait a few weeks before beginning.

Phase 2 – After the workshop

Step 6: Get started using GLOBEMail

After you finish the GLOBE training session, you should begin to implement the standard GLOBE protocols and learning activities. You can begin to use GLOBEMail at any point.

Send a hello message to your colleagues. You should also begin to receive messages from your colleagues.

GLOBEMail

To: Seasonal Markers Team

From: School name

It is June 12, and the monsoon rains have just begun. This is when we typically have a big party, dancing in the rain. Did you know that the word monsoon is derived from "mausim" which is the Arabic word for season?

Step 7: Send a GLOBEMail message whenever a seasonal marker occurs

With your students, pay attention to the environment around you, noticing when each of the seasonal markers occurs. Whenever it does, send a GLOBEMail message to your seasonal markers teammates, indicating the marker, the date and any other comments you and your students would like to add.

Step 8: Monitor your incoming GLOBEMail for messages, and plot the data

Whenever you receive a GLOBEMail message from one of the participating schools, have your students record the information on a map. You might want to have a different map for each of the seasonal markers. You might also want your students to make a chart listing each marker and the location and date of each observation.

Step 10: Conduct your own investigations!

As you and your students do your own local observations, and as you peruse the observations from the other schools, you and your students may notice some patterns. For example, they may notice that the further south a school is, the sooner they see the first spring robin. Or they may notice that lakes freeze sooner inland than near the coast. Have your students use GLOBEMail to share these speculations with the other schools.

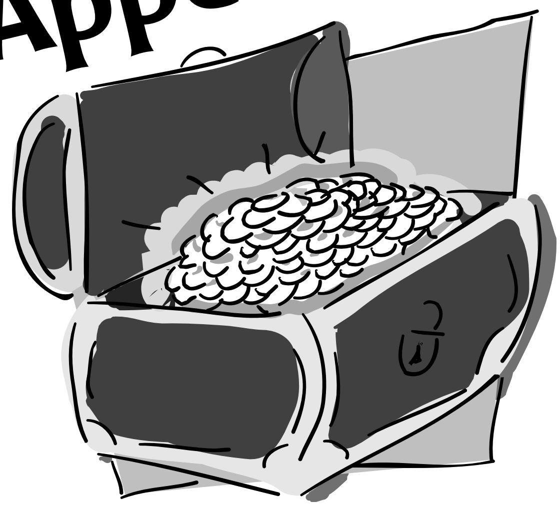
Your students should also use GLOBE's data server to explore GLOBE student data which might provide further insights into the seasonal patterns. They might find that the coldest day of the year is generally one month after the Winter solstice. Or they might find that robins only start to appear after the local temperature has reached an average of 40 deg F. Use GLOBEMail to share these speculations with the other schools.

Your students can extend these investigations with seasonal data. They might find patterns linking

GLOBE data with seasonal markers. They might predict when a particular marker will occur and see how close their guess is to reality. They also can relate the seasonal markers with the other seasons activities described elsewhere in this module.

GLOBE is a wonderful resource for conducting a wide range of investigations. The seasonal markers investigation provides you and your students the opportunity to participate in your own investigations, to share observations and ideas with other schools, and conduct collaborative investigations with other schools around the world. Also, GLOBEMail enables you, as a teacher, to provide mutual support with other teachers as you implement GLOBE. Most importantly, this activity enables you and your students to experience and participate in the excitement of science research enabled by GLOBE's world-wide network of students, teachers and scientists.

Appendix



Pedagogy of the Seasons Investigation

Locating Information on the GLOBE Student Data Server

Mini-Investigation: How Can One Tell Whether Two Parameters Are Interrelated?

Pedagogy of the Seasons Investigation

In the Seasons Investigation, each activity starts with a sequence of highly structured steps. However, as each activity progresses, students get increasing amounts of freedom to conduct their own investigations. This approach prepares students to conduct their own research by developing the necessary skills, deepening their understanding of key concepts, and helping them generate interesting questions worthy of further study.

How This Activity Helps Develop the Idea that Science is a Process of Refining Understanding

General Steps in Refining Understanding

1. Ask Questions and Develop Hypotheses
2. Plan Investigation
3. Collect and Analyze Data
4. Draw Conclusions
   If data are insufficient to support conclusion, return to 3
   If data are sufficient to support a conclusion, go to 5
5. Communicate conclusions
6. Ask follow-up Questions and Develop New Hypotheses

Locating Information on the GLOBE Student Data Server

To Find Any GLOBE Site

1. Click on the "Student Data Server" on the GLOBE Home Page
2. Use the menus to locate the site(s).

If there are only a few sites at your latitude, another approach to finding sites is to have students identify major cities around the world at their latitude. Daily high and low temperatures for such cities are printed in the weather section of most newspapers. However, many major cities are coastal, so make sure students obtain some kind of diversity.

Finding a Nearby GLOBE School

1. Click on the "people" icon (fifth button) on the button bar at the bottom of the GLOBE home page.
2. Scroll to the bottom of the "GLOBE School Interaction" page and click on the "List" button.
3. The next menus will enable you to select the appropriate country and state.
4. When you are at the "Individual School" level, scroll through the list to find a nearby school that has a data icon (a picture of a graph in the third column).
5. Click on the data icon and see how many data points exist for the parameter in which you are interested. If it does not have enough data points or if the data points are for the wrong time period, continue to scroll through the list until you find a data set that meets your needs. If no school in your state meets your needs, consider using data sets from schools at similar latitudes in similar geographical settings. While this will introduce an uncontrolled variable into your data, it will also stimulate an interesting discussion about weather and climate around the world. In addition, it will underscore the importance of submitting to GLOBE a data set to represent your region.

To Find the GLOBE Sites That Have Reported on a Specific Day

1. Click on the Student Data Archive on the GLOBE Home Page.
2. Use the "Get data for most recent day or for some other time period" menu to locate the site.

Another Way To Find the GLOBE Sites that Have Reported on a Specific Day

1. Open the GLOBE Visualizations location on the GLOBE Student Server.
2. Click on "What's New."
3. Click on "try out new system."
4. Select "GLOBE Maps."
5. Scroll down and under "Other Options," click on "Show Table."
6. The list is at the bottom of the page. Click on the column headings to sort the table by that category.

Finding GLOBE Sites With Many Reported Measurements

1. Select "GLOBE Stars" on the Student Data Server home page.
2. Select "Schools providing many observations."
3. Click on the arrow to find the name of the schools in each category.
4. Click on one of the icons to access a school's data or to find out more about the school.
5. So a data-rich site can be readily identified when data from a specific location is required, print out the schools in each category and keep them on file.

Obtaining Average Monthly Data

1. From the GLOBE Home Page, click on the "Student Data Archive."
2. Enter the first few letters of the school you want.
3. Click: "Search."
4. After the search is completed, click on the data icon of the desired school.
5. After clicking the checkboxes of the "Monthly Summary" and desired measurements, click "Retrieve."
6. Once the monthly summary data are obtained, they can graphed by hand or be loaded into a spreadsheet program.

Obtaining Historical Data through GLOBE

In this activity, students will see importance of having reliable data over long periods of time and will appreciate the insights that can be gleaned from using the historical climatic data on the GLOBE Student Server. To access these data:

1. Click on the "GLOBE Resource Room" selection on the GLOBE Home Page.
2. Click on "Weather Information."
3. Choose a site with historic weather data such as Intellicast or the Purdue Weather Processor. Scroll down to the bottom of the Weather Information page to see capsule descriptions of each weather site.

Another historic temperature and precipitation data set provided through GLOBE is from the National Climatic Data Center. It includes historic temperature data from over 6,000 stations around the world dating back hundreds of years, in some cases. The data are available in several presentations: as an average year, as a yearly time series, and as monthly averages. One can also obtain the average and standard deviation of temperatures shown as a function of latitude. These data provide an original data source for discussions of temperatures and seasonal variations around the world.

Mini-Investigation

How Can One Tell Whether Two Parameters Are Interrelated?

Overview

Students create climatographs for their site and the two sites examined in the *What Are Some Factors That Affect Seasonal Patterns? Learning Activity*. They analyze each climatograph to determine if temperature and precipitation patterns are interrelated. Students then examine how the three sites are alike and different based on their temperature and precipitation patterns. Finally, students generate ideas about what might cause the patterns to be different. They repeat this process with other parameters.

Procedure

Step 1: Have student groups obtain the monthly summaries of the *Atmospheric Temperature*, *Precipitation Rain*, and, if appropriate, *Precipitation Solid* data from your site and the two sites examined in *What Are Some Factors That Affect Seasonal Patterns? Learning Activity*.

Note: You can either provide students print outs or have them use the Student Data Archive to obtain these data. If your site has limited amounts of data, use the menus in the Student Data Archive home page to find a nearby GLOBE site whose data you can use. To generate a table of monthly summaries, see *Obtaining Average Monthly Data* in the *Appendix*.

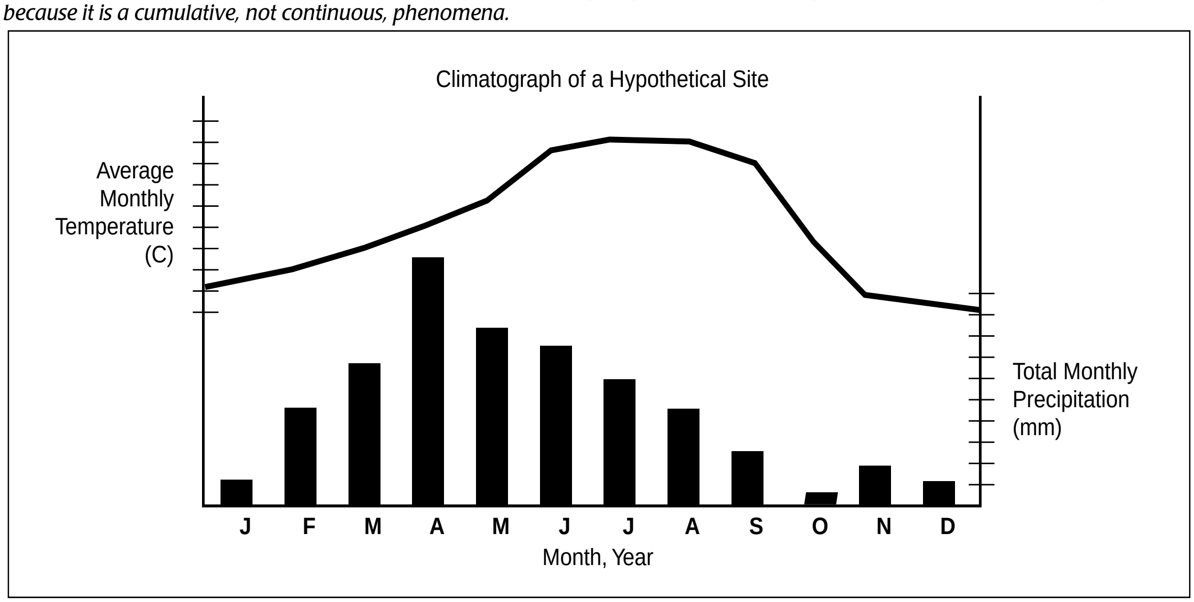
Step 2: If any of these sites have *Precipitation Solid* data (i.e., snow and ice), have students calculate the total amount of precipitation for each month by adding *Water Equivalent* column (under *Precipitation Solid*) to the *Precipitation Rain* column.

Step 3: For each site, have students plot the *Average Current Temperature* and the total precipitation (i.e., *Precipitation Rain* plus *Precipitation Solid —Water Equivalent*) month-by-month onto a single graph for a year. See Figure SE-A-1.

Note: All three average monthly temperatures – the current, maximum and minimum – will show annual trends equally well, and you can have students plot any one of them. Make sure each student puts a copy (hand-written or a print out) of each graph in his or her GLOBE Science Notebook.

Step 4: Have students analyze each graph. See how well they can analyze them on their

Figure SE-A-1: A Climatograph displays a site's temperature and precipitation levels. Precipitation is shown with a bar graph because it is a cumulative, not continuous, phenomena.



own. If they need prompting, ask questions such as:

- When does the wettest month occur? The driest? The hottest? The coldest?
- How is the precipitation distributed over the year?
- What are the maximum temperature and precipitation values? The minimum?
- What temperature range is associated with the maximum precipitation levels? The minimum?

Note: Have students do their analysis of the three sites in small groups and then develop a class-wide understanding of each site by having them share their analyses in a class discussion. The analysis can also be assigned as homework.

Step 5: For each site, have students write a summary statement in their GLOBE Science Notebooks about whether the precipitation and temperature patterns at each site are interrelated. Also, have them write three to five questions relating to temperature and precipitation patterns.

Note: Patterns are said to be interrelated when a change in one causes a change in the other. However, the patterns need not be identical. For example, when temperatures in many regions are at their highest, the precipitation levels are at their lowest. Even though these patterns are opposite, they are still interrelated because when the hot season ends and temperature levels fall, the precipitation levels usually increase. This cause-and-effect relationship is what characterizes interrelated phenomena.

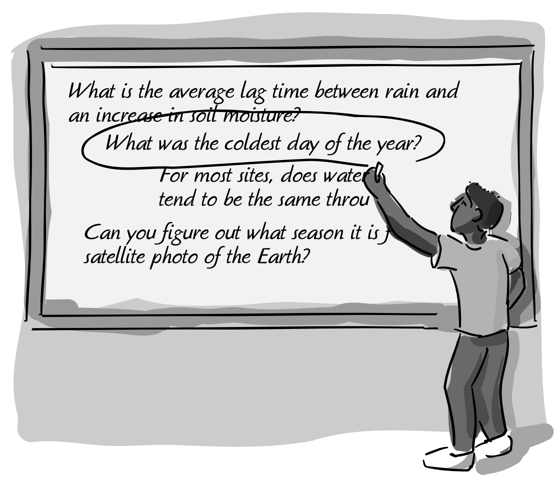
Step 6: Have students compare the three climatographs by creating lists of how the three sites are alike and different. See how well they can analyze them on their own. If they need prompting, ask questions such as:

- In general, which site is the hottest? The coldest? The wettest? The driest?
- In what way are the patterns on the three climatographs most alike? Most different?
- Describe each season based on the temperature and precipitation patterns at these sites.
- Describe the plant and animal life one might find at the distant site.
- Describe how the temperature and precipitation patterns might affect how people live at the distant site.
- What kinds of climates are represented by each of the climatographs? (Ask only if students are sufficiently prepared to answer this question.)

Note: Have students do their initial analysis in small groups and then develop a class-wide understanding of each site by having them share their analyses in a class discussion. The analysis can also be assigned as homework.

Step 7: Have students write a hypothesis in their GLOBE Science Notebooks about what they think causes annual temperature and precipitation patterns at the three sites to be different. Also, have them write three to five questions relating to temperature and precipitation patterns at different sites around the world.

Note: *What Are Some Factors That Affect Seasonal Patterns? Learning Activity* explores how latitude, elevation and geography influence annual patterns. Differences in any of these factors will cause differences in the annual temperature pattern. Since precipitation is



based on a relationship between temperature and the amount of water vapor in the air, anything that influences either of these factors will influence precipitation levels. See *Two Key Factors That Influence Precipitation Levels* in the background section for a more complete discussion.

Step 8: Have students share some of their hypotheses and questions relating to temperature and precipitation patterns and create a master list. If questions such as the following do not emerge, add them to the list.

- Are temperature and precipitation levels interrelated?
- Do temperature and precipitation levels follow similar patterns around the world?
- Why are precipitation patterns at the distant site different from those at our site?
- Are precipitation levels influenced by latitude, elevation and geography the way temperature levels are?

Note: Use a wall map of the world or the maps found under GLOBE Visualization to focus attention on differences in latitude and elevation, and in proximity to oceans and other significant geographic features.

Step 9: Following a procedure similar to the one outlined in Steps 3-8, have students choose other GLOBE parameters and investigate how their annual patterns are related to the temperature and precipitation levels.

Step 10: In their GLOBE Science Notebooks, have students write a statement about how the parameters measured in GLOBE are interrelated.

Extension

- Consider having students investigate some of the hypotheses developed in Steps 8 and 9.
- By creating climatographs for sites around the world, challenge students to identify as many different kinds of climates as possible. See the ten climatographs in Figure SE-A-2.

Assessment

By the end of this activity, students should be able to use graphs and data to:

- create a climatograph;
- analyze a climatograph to understand a site's temperature and precipitation patterns;
- make reasonable inferences about a site's plant and animal life based on its climatograph;
- support the claim that seasonal patterns are influenced by a combination of latitude, elevation and geography;
- show that the annual patterns of the parameters measured in GLOBE are interrelated.

Figure SE-A-2: Sample Climatographs: Patterns Associated with Different Climates